REPORT RESUMES

ED 019 233 SE 003 934

REORGANIZED SCIENCE CURRICULUM, 5A, FIFTH GRADE SUPPLEMENT.

MINNEAPOLIS SPECIAL SCHOOL DISTRICT NO. 1, MINN.

PUB DATE 1 DEC 64

EDRS PRICE MF-$0.75 HC-$5.12 126P.

DESCRIPTORS- *CURRICULUM DEVELOPMENT, *CURRICULUM, *ELEMENTARY SCHOOL SCIENCE, *GRADE 5, *TEACHING GUIDES, ASTRONOMY, BIOLOGY, EARTH SCIENCE, INSTRUCTIONAL MATERIALS, PHYSICAL SCIENCES, SCIENCE ACTIVITIES, SCIENCE COURSES, MINNEAPOLIS, MINNESOTA,

THE SEVENTH IN A SERIES OF 17 VOLUMES, THIS VOLUME PROVIDES THE FIFTH GRADE TEACHER WITH A GUIDE TO THE REORGANIZED SCIENCE CURRICULUM OF THE MINNEAPOLIS PUBLIC SCHOOLS. THE MATERIALS ARE INTENDED TO BE AUGMENTED AND REVISED AS THE NEED ARISES. THERE IS A DETAILED OUTLINE OF SUBJECT MATTER FOR GRADE 5 FOR EACH OF THE FOLLOWING MAJOR AREAS AROUND WHICH THE PROGRAM IS DESIGNED--(1) THE EARTH, (2) LIVING THINGS, (3) ENERGY, AND (4) THE UNIVERSE. A CHART INDICATES GRADE CONTENT FOR THE ENTIRE K-12 PROGRAM. THE FIFTH GRADE SUPPLEMENT IS IN TWO VOLUMES, 5A CONTAINING THE SECTIONS ON (1) CONCEPTS, AND (2) RESOURCE UNITS, AND VOLUME 5B CONTAINING THE BIBLIOGRAPHIES AND EQUIPMENT AND SUPPLIES SECTIONS. THE RESOURCE UNITS INCLUDE DESCRIPTIONS OF UNITS DEALING WITH (1) HEAT AND INFRARED RADIATION, AND (2) THE UNIVERSE. THE LATTER IS DIVIDED INTO THE FOLLOWING SUBSECTIONS--(1) EARTH, (2) MOON, (3) SUN, (4) SOLAR SYSTEM, AND (5) STARS AND GALAXIES. (DH)

SE003 934

ED019233

SCIENTIFIC APPROACH TO PROBLEM SOLVING

1. Observation--first-hand experiences and observations.
2. Definition of PROBLEM--ask questions, choose one for investigation.
3. Results of other investigators--read about problem, discuss it with interested friends and resource people, examine the written material.
4. Possible solutions--list all possible guesses.
5. Choosing the best solution (HYPOTHESIS)--pick the "best guess".
6. Testing the hypothesis--planning and carrying out EXPERIMENTS to determine its truth.
7. CONCLUSION of accepting or rejecting hypothesis--draw conclusion from experiments to determine acceptance or rejection of "best guess".
8. More extensive testing of hypothesis--experiment further to determine if hypothesis always holds true.
9. Stating the THEORY and publishing results--restate the hypothesis in light of the above experimentation, publish in professional journal.
10. Finding mathematical proof--do any measuring and mathematical calculations to develop proof of theory.
11. Statement of LAW or PRINCIPLE--if no one can find a mistake in the mathematical proof or develop a contrary proof, the theory becomes a law or principle.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

THE FIFTH GRADE SUPPLEMENT

to the

REORGANIZED SCIENCE CURRICULUM

Kindergarten Through Grade Twelve

(For Discussion Purposes Only)

BOARD OF EDUCATION

Stuart W. Rider, Jr., Chairman
Mrs. Charles Hymes, Clerk
Lawrence E. Johnson
Richard S. Larson
Florence Lehmann
David W. Preus
John M. Warder

Rufus A. Putman, Superintendent

MINNEAPOLIS PUBLIC SCHOOLS
special school district no. 1
Minneapolis, Minnesota

"PERMISSION TO REPRODUCE THIS
COPYRIGHTED MATERIAL HAS BEEN GRANTED
BY J. Hervey Shutts
Minn. Public Schools
TO ERIC AND ORGANIZATIONS OPERATING
UNDER AGREEMENTS WITH THE U.S. OFFICE OF
EDUCATION. FURTHER REPRODUCTION OUTSIDE
THE ERIC SYSTEM REQUIRES PERMISSION OF
THE COPYRIGHT OWNER."

Publication Rights Reserved By

MINNEAPOLIS PUBLIC SCHOOLS
special school district no. 1
Minneapolis, Minnesota

December 1, 1964

FOREWORD

Long before that famous October fourth, 1957, when Sputnik I rocketed into orbit, the science teachers of the Minneapolis Public Schools eagerly began work on the reorganization of the science curriculum from kindergarten through grade twelve. This reorganized science curriculum was requested by our instructional staff and developed by representative members of that staff.

The citizen of today must be science literate in order to exercise adequately his duties of citizenship. The contribution of the scientist to our way of life is the methods which he uses to attack a problem and seek its solution. These methods are unique, but more important, they are very useful; they can be applied in the solution of the everyday problem by knowledgeable children at all ages and grade levels, and by adults in all walks of life. If these methods of science are to be learned by the youth of Minneapolis, they must be learned by attacking realistic problems inside and outside the classroom. This practice in the solving of work-a-day problems trains our young citizens to think for themselves in seeking new solutions to age-old problems of our civilization.

In the Minneapolis Public Schools we recognize that science is a very important part of the liberal arts general education which should be studied by all students. We are aware of our responsibility for instruction which must be well grounded in the fundamental laws and principles in all the fields of the basic sciences and therefore propose this reorganized curriculum for teaching the ever-expanding knowledge of science.

This reorganized science curriculum does not teach itself. It is a planned developmental approach in which the teacher is the expeditor and not the limiter of learning. The curriculum has been developed to aid the student in acquiring new breadths and new depths of understanding of his environment; and with it a teacher who is well trained in science may lead the student in an ever-expanding investigation of his surroundings in this world and universe. If the curriculum is used cooperatively by teacher and students, it is an instrument which can mold a pupil of the Minneapolis Public Schools into a science-literate citizen who, if he continues advanced science training, may become a scientist of the future.

Rufus A. Putnam
Superintendent of Schools

FOREWORD

Long before that famous October fourth, 1957, when Sputnik I rocketed into orbit, the science teachers of the Minneapolis Public Schools eagerly began work on the reorganization of the science curriculum from kindergarten through grade twelve. This reorganized science curriculum was requested by our instructional staff and developed by representative members of that staff.

The citizen of today must be science literate in order to exercise adequately his duties of citizenship. The contribution of the scientist to our way of life is the methods which he uses to attack a problem and seek its solution. These methods are unique, but more important, they are very useful; they can be applied in the solution of the everyday problem by knowledgeable children at all ages and grade levels, and by adults in all walks of life. If these methods of science are to be learned by the youth of Minneapolis, they must be learned by attacking realistic problems inside and outside the classroom. This practice in the solving of work-a-day problems trains our young citizens to think for themselves in seeking new solutions to age-old problems of our civilization.

In the Minneapolis Public Schools we recognize that science is a very important part of the liberal arts general education which should be studied by all students. We are aware of our responsibility for instruction which must be well grounded in the fundamental laws and principles in all the fields of the basic sciences and therefore propose this reorganized curriculum for teaching the ever-expanding knowledge of science.

This reorganized science curriculum does not teach itself. It is a planned developmental approach in which the teacher is the expeditor and not the limiter of learning. The curriculum has been developed to aid the student in acquiring new breadths and new depths of understanding of his environment; and with it a teacher who is well trained in science may lead the student in an ever-expanding investigation of his surroundings in this world and universe. If the curriculum is used cooperatively by teacher and students, it is an instrument which can mold a pupil of the Minneapolis Public Schools into a science-literate citizen who, if he continues advanced science training, may become a scientist of the future.

Rufus A. Putnam
Superintendent of Schools

INTRODUCTION

This Supplement has been prepared as a convenient reference to assist the fifth grade teacher in teaching the science content allocated in the Reorganized Science Curriculum. Fifth grade teachers suggested and assisted with the preparation of each section of this Supplement. Those who have participated in the preparation of this Supplement lay no claim to its being "without blemish". However, its value can be determined only by those classroom teachers who use it and make constructive suggestions to improve it. All Minneapolis Public School personnel are invited to cooperate in improving this Supplement in order to make it of genuine assistance to all beginning and experienced fifth grade teachers. All constructive suggestions should be called in or sent to the Science Department Office.

This Supplement is not complete at the present time. When additional materials are developed, a copy will be furnished to you to place in this loose-leaf binder. Your cooperation with us to keep your Supplement up-to-date will be appreciated. When you leave your school, please leave the Supplement for the next teacher's use.

For discussion
purposes only

SUMMARY OF GRADE-CONTENT ASSIGNMENTS

Area and Major Topics	Grade Level												
	K	1	2	3	4	5	6	7	8	9	10	11	12
Introduction to Science (Gray)	*	*	*	+	*	*	*	+	+	+	+	+	+
A. Attitudes (Including history)	+	+	+	+	+	+	+	+		+			+
B. Tools	+		+	+	+		+		*				+
C. Methods	+		+	*	+	+	+			*			
I. The Earth (Red)	+	+	+	*	*	+		+	*				
A. History of the earth					+				+				
B. Physical features	*	+		+	+				+				
C. Rocks and minerals	+	*			+				+				
D. Soils		+		+	+				+				
E. Water	*		*	+	*			*					
F. Air	+	*		+	*			*					
G. Weather and climate				+		*			*				

Key to symbols -- * major emphasis
+ content to be taught

For discussion purposes only

Area and Major Topics	Grade Level											
	K	1	2	3	4	5	6	7	8	9	10	11
II. Living Things (Green)	+	+	+	+	+	+		*			*	
A. Life and life processes	+	+	+	+		*		+			+	
1. Life in general	+			*		+		+			+	
2. Food taking or nutrition		*	*	+		+		+			+	
3. Digestion								+			+	
4. Absorption						+		+			+	
5. Circulation				+		+		+			+	
6. Respiration						+		+			+	
7. Assimilation								+			+	
8. Oxidation						+		+			+	
9. Excretion				+		+		+			+	
10. Reproduction and growth		*	*	*		+		+			+	
11. Responsiveness	+	*	+	+		+		+			+	
B. Classification	*	+	+	+		*		+			+	
C. Ecology	*	+	*	*	*			+			+	
D. Plant and animal economics	+	+	+	*	*			+			+	
E. Human body	*	*	*	*		*		*			+	
F. Aesthetic values	*			*				+			+	

(continued)

Grade-content assignments (continued)

Area and Major Topics	Grade Level												
	K	1	2	3	4	5	6	7	8	9	10	11	12
III. Energy (Yellow)	+	+	+	+	+	+	+			+		*	+
A. Properties of matter related to energy	+			*			*			*		+	*
B. Sources and conservation of energy	+			+		*				+		+	+
C. Mechanical energy and simple machines	*		*	*			*			*		+	
D. Gravitational energy	+			+			+			+		+	
E. Magnetic energy	*		*	+	*					+		+	
F. Sound		*	*				*			+		+	
G. Electrical energy		*		*		*				*		*	
1. Static						+				+		+	
2. Current		*		*		+				*		+	
H. Communication bands and electronics												+	
I. Heat and infrared radiation	*			*		*				+		+	
J. Light and ultraviolet radiation	*	*	*				*			+		+	
K. High energy waves												+	
L. Chemical energy				+			*			*			*
M. Atomic energy							+			+		+	*

For discussion purposes only

Area and Major Topics	Grade Level												
	K	1	2	3	4	5	6	7	8	9	10	11	12
IV. The Universe (Blue)	+	+	+	+		*	+		*	+			
A. Earth	+	*	*	*		+			+				
B. Moon	*		*			+			+				
C. Sun	*	*	*	*		+			+				
D. Solar system						+			+				
E. Stars and galaxies	*		*	*		+			+				
F. Space travel		+	+	+			*			*			

Key to symbols - - * major emphasis

+ content to be taught

Note: Conservation and safety must permeate science teaching at all grade levels.

Copied by JW
5-27-63

SUBJECT MATTER ALLOCATION

Grade Five

For discussion
purposes only

SUBJECT MATTER ALLOCATION

Grade Five

Note: This report recommends an order of presentation of science content and summarizes the concepts found in the Handbook. The examples used to illustrate each item are intended to stimulate thought association and not to restrict the presentation of this material.

INTRODUCTION TO SCIENCE

Attitudes (including history)

relationship of curiosity to solution of scientific problems--systematic observation, cause and effect inquiry, teamwork in research

Methods

importance of careful methods of investigation to scientific progress--repeated experiences, critical evaluation, use of methods of science

THE EARTH

Weather and climate

factors which determine weather--temperature differences in the air, movement of air masses, uneven heating of areas on the earth

changes in weather conditions--continual changes, weather fronts

factors observed to collect weather data--precipitation, wind, humidity, cloud types, barometric pressure

effect of geographic features on weather--ocean currents, altitude, latitude

prediction of weather--weather map, weather records

relation of weather to climate--daily conditions versus long time average

types of climates and seasons--wet and dry seasons, equatorial climate

ENERGY

Sources and conservation of energy

- sources and forms of energy--sun, wind, water, energy of position and motion, chemical energy, electrical energy, light energy
- man's historical development of the sources of energy--muscle energy, water power, wind power, nuclear energy
- need for wise use of energy resources--fuels and other energy sources
- effect of energy on matter--change in direction and speed of movement

Heat and infrared radiation

- sources and transfer of heat energy--solar, combustion; radiation, conduction, convection
- factors which affect absorption and radiation of heat--surface area, color
- control of heat energy--thermostat, use of cooling devices
- measurement of temperature--thermometer, various temperature scales
- factors which affect rate of evaporation--temperature, ventilation, surface area

Electrical energy

- production, effects and uses of static electricity--sparks, Cottrell precipitator
- formation, effects and control of lightning--raindrop formation, thunder, lightning rods
- sources, transfer and control of current electricity--dry cells, generators; conductors, resistors, insulators; fuses, circuit breakers, switches, grounding devices
- detection and measurement--galvanometers, ammeters, voltmeters
- effects of current electricity--heat, light, magnetic, chemical
- uses of current electricity--toaster, light, door bell, electroplating, motor
- kinds of circuits--open and closed circuits, short circuits, series, parallel
- uses of electromagnets--telegraph, motors, electric buzzer

THE UNIVERSE

Earth

characteristics of the earth--size, atmosphere, characteristics of its core, gravitational field

kinds and effects of the earth's movements--rotation, revolution; bulge at equator, seasons

astronomical measures of time--day, year, season

influence of other astronomical bodies on earth--tides, light

Moon

physical characteristics of the moon--size, composition, surface features, temperature, gravitational force

relation of moon to earth--distance, orbital path

changes in appearance of the moon--cause of moonlight, phases, causes of phases, eclipses

Sun

physical description of the sun--location, size, age, temperature

intensity and kinds of radiation--brightness, white light, heat, sunspots

effects of sun on earth--photosynthesis, length of day, seasons, temperature of earth, changes in magnetic field

Solar system

early study of solar system--discovery of outer planets

members of the solar system and their movements--planets, meteors, comets; rotation, revolution

comparison of characteristics of members of solar system--various lengths of day and year, size, number of satellites

characteristics of comets and meteors--comet's "tail", meteorites

causes and frequency of eclipses--lunar eclipse, solar eclipse

Stars and galaxies

increase in knowledge of the universe--early false conclusions

tools for study of the universe--telescopes, planetarium

use of constellations--locating objects in sky, telling time and direction at night on earth

identification of constellations--folklore, independent movement of their stars actual and apparent movement of stars--galaxy systems, binaries, circumpolar, velocity of movement

factors which determine ease of observation--distance, size, weather conditions

characteristics of stars--brightness, color, appearance as viewed from earth

galactic systems--shape, appearance, collection of stars

characteristics of Milky Way galaxy--size, shape, movements

LIVING THINGS

Life and life processes

characteristics which all living things and all cells have in common--basic life processes such as nutrition, circulation, respiration, sensitivity, absorption of water

organs of respiration, excretion, or sensitivity in some plants and animals--gills, stomata, lungs, eyes, tongue

life cycle of plants and animals--growth, metamorphosis of insects

insects--growth characteristics, relation to other organisms

methods of vegetative reproduction of plants--slips, budding

plant reproduction by seed formation--reproductive structures, pollination

internal and external conditions which affect living things--reacting to changes, heat, sound, hunger, fear

Classification

grouping of plants and animals--on the basis of structure and function, seasonal changes, usefulness to man, amount of care given young

effects of habitats on living things--habitat types, communities

common methods of food getting or food making--photosynthesis, parasites versus saprophytes

means by which an organism may act to secure more favorable conditions--movement, hibernation, migration

Human body

nutritional requirements--minerals, protein, digestion of foods

control of destructive organisms by removal of habitat--care of wounds, covering mouth during sneeze, brushing teeth

body's defenses against disease; effect of harmful living things on man--lining of nose; bacteria, poisonous mushrooms

factors which affect body's comfort--type of clothing, perspiration

effects of ultraviolet light--sunburn, "tan"

functions of different types of teeth

CONCEPTS

For discussion
purposes only

Grade Five

ALLOCATION OF CONCEPTS BY MAJOR TOPICS

Note: This report recommends an order of presentation of science content at each grade level and changes the order of the concepts found in the Handbook to provide a logical teaching approach.

Fall

Introduction to Science

For this unit it might be helpful to review the concepts taught under the topic of "Introduction to Science," in grade four.

A. Attitudes (including history)

1. Teamwork in scientific research is becoming more common.
2. Accurate observations made incidentally during investigation of a problem often supply information valuable in the solution of other problems.
3. A scientific person believes that every effect has a natural cause.
4. Scientific curiosity may be satisfied by systematic investigation.

C. Methods

1. Scientific investigation may begin with the statement of a clearly-defined problem.
2. Scientists may investigate a problem from many different viewpoints but generally use most of the steps included in the statement of "The Scientific Method".
3. Various kinds of investigation are involved in scientific study.
4. A variety of repeated experiences and observations are necessary before valid generalizations are made.
5. Careful observation usually results in accurate recordings and possible solutions.
6. A scientist critically evaluates an idea before it is accepted.
7. Incomplete data often leads to invalid conclusions.
8. A scientist may summarize conclusions in the form of a hypothesis.
9. The methods used in trying to discover the laws of nature are the methods of science.

Fall

I. The Earth

G. Weather and climate

1. Weather varies from day to day depending upon atmospheric conditions.
2. Early weather predictions were usually weather sayings based on observations.
3. Some weather sayings are based on scientific fact; others are superstitions based on incorrect observations.
4. Forecasters can predict the weather fairly accurately by studying weather maps, records and charts.
5. Weather data are plotted on weather maps by using various symbols.
6. The average weather conditions over a long period of time determine the climate.
7. Weather maps record and chart atmospheric data.
8. Climates are usually classified according to temperature and moisture characteristics.
9. For convenience of study, man has given specific names to various types of climates on the earth; e.g., equatorial, subtropical, temperate, polar.
10. Various geographical influences on weather and climate are large bodies of water, latitude, altitude, and ocean currents.
11. The sun does not deliver the same amount of energy to each area of the earth.
12. The change in height of the sun during the year is caused by the seasons.
13. The sun's rays strike at a different angles at different latitudes.
14. Land areas absorb and give off heat faster than water areas.
15. Land and water areas are heated unevenly, causing the air above to be heated unevenly.
16. Air masses heated unevenly set up convection currents known as winds.
17. The temperature of the air depends upon the winds, the nature of the earth's surface, and the season of the year.
18. Conditions of the atmosphere vary from place to place.
19. Atmospheric conditions at a given location are constantly undergoing change.
20. Heated air expands and becomes lighter.

21. Cooled air contracts and becomes heavier.

22. Higher altitudes near the earth's surface are cooler because the air is less dusty and less humid.

23. Masses of cold or warm air usually blow from a westerly direction across the continent.

24. Changes in weather usually occur along fronts that develop where air masses meet.

25. The leading edge of the warm air mass usually brings warm weather.

26. The leading edge of a cold air mass usually brings cold weather.

27. Air moving from high to low pressure areas is called wind.

28. Low pressure areas are usually characterized by warm, cloudy, and often stormy weather.

29. High pressure areas are usually characterized by cool, clear weather.

30. The higher the temperature of air, the more water vapor it can hold.

31. Dew, frost, and fog are produced near the earth's surface directly from the air.

32. Clouds can be classified according to shape and elevation.

33. Rain, sleet, hail, and snow may be formed when particles of water are too big to float in the air as clouds.

34. Human health and comfort is influenced by the relative humidity of the air.

35. The structure and responses of plants and animals enable them to withstand a certain amount of change in temperature and the amount of moisture.

Fall and Winter

III. Energy

Sources and conservation of energy

1. Energy is the ability or capacity to more or change things.
2. Nothing that is done can be done without the knowledge of how to harness energy.
3. Natural sources of energy are the sun, wind and water.
4. Burning fuel releases energy.
5. Inefficient use and wasteful release of energy rapidly decrease our natural resources.
6. Some natural forms of energy are not usable to man at present.
7. Some forms of energy which man might use for energy have not yet beem utilized.
8. Early man could supplement his energy for accomplishing work only by the use of other men's muscle energy and that of the beasts of burden.
9. The most common form of energy used by man during early civilization was mechanical energy.
10. Today man uses chemical, electrical and nuclear energy to supplement the energy of muscles.
11. Gravitational attraction causes water to fall to lower levels (toward the center of the earth).
12. The energy of falling water may be used to do useful work as in the turning of water wheels and turbines.
13. Movement of matter requires energy.
14. Motion is an example of energy.
15. Force is required to change the direction of a moving object.
16. Force is required to change the speed of a moving object.
17. Unequal heating of the various parts of the earth causes winds.
18. Light energy may be changed into other forms of energy.
19. Light energy may be changed to food energy by the chlorophyll in plants.
20. Fossil fuels and plant foods contain stored chemical energy which comes to us indirectly from the sun.
21. Food contains stored chemical energy.

22. Most of the food which man eats is converted into energy for life.

23. Energy can be observed and measured by its action on matter.

24. Matter is a form of energy.

25. The atom contains vast quantities of energy.

I. Heat and infrared radiation

1. Warm objects are continually radiating energy (radiation).

2. Increasing the surface area of a heated object usually increases the rate of heat dissipation.

3. Rough surfaces are good absorbers and radiators of heat.

4. Dark-colored substances absorb heat more readily than light-colored substances.

5. Dark-colored substances give off heat more readily than light-colored substances.

6. Objects exposed to the sun usually cool when the sun no longer shines on them.

7. Heat travels through various materials (conduction).

8. Air near hot objects becomes heated and transfers the heat elsewhere (convection).

9. Heat may be directed by reflection.

10. Evaporation of water results in a cooling effect.

11. Increasing the temperature usually increases the rate of evaporation.

12. Increasing the rate of air movement usually increases the rate of evaporation.

13. Increasing the surface area usually increases the rate of evaporation.

14. Increasing ventilation or circulation of air usually increases the evaporation of moisture from the skin.

15. Devices which produce large quantities of heat must be equipped with controls.

16. Foods are preserved by various cooling and freezing processes.

17. Light energy, when it is absorbed, may change into heat.

18. Some of the energy of former sunlight is stored in our fossil fuels.

19. Man is using solar energy for cooking and heating.

20. Temperatures can be measured by various instruments.

21. Temperatures may be expressed in various temperature scales.

G. Electrical energy

1. Electricity is a form of energy.

2. Static electricity is present when one object has a deficiency of electrons (+) or an excess of electrons (-).

3. Static electricity is usually produced when two non-conducting materials are rubbed together.

4. Some electrons may be moved from one non-conductor to another by rubbing them together.

5. Like electrical charges repel and unlike electrical charges attract each other.

6. Some electrically charged objects attract uncharged objects.

7. Static electrical charges may result in a spark.

8. Lightning is a huge electrical spark in the air.

9. Lightning is the result of released static electricity.

10. The sudden release of heat in our atmosphere by lightning causes rapid expansion of the air resulting in the sound of thunder.

11. Lightning strikes the tallest objects.

12. The static electricity which causes lightning is generated by the formation of raindrops.

13. An electrical charge in a rain cloud passing nearing the earth causes an opposite charge to form on the earth directly below the rain cloud.

14. If the electrical charge on a rain cloud passing near an uncharged or oppositely charged object becomes great enough, an electrical discharge (lightning) occurs which releases a great deal of energy.

15. Devices commonly used to protect some of man's property from lightning damage usually depend on the conductivity of metals.

16. During electrical storms the lightning rod conducts the excess of electrons to gradually discharge the rain clouds.

17. Electrical charges may be transferred from a charged object to an uncharged object by conduction.

18. Lightning rods gradually conduct electrons from the ground to electrically charged clouds or from the clouds to the ground.

19. Lightning rods, to be effective, must have sharp pointed upper terminals and the lower end buried deeply in moist earth.

20. All electrical appliances in the home and factory should be grounded.

21. In electrical circuits very often a conductor is connected to a water pipe or other grounding device.

22. The earth may be used to complete a circuit.

23. The ground wire on electric circuits and electrical appliances prevents electrical shock.

24. Static electricity may be useful to man.

25. Electrical energy may be stored.

26. A current of electricity is produced when electrons are moved.

27. Current electricity is the flow of electrons from a source with an excess of electrons to a place where there is a deficiency of electrons.

28. Electric current takes the path of least resistance.

29. Some metals are good conductors of electricity.

30. A good electrical conductor is one which contains many free electrons which may be moved easily from one atom or molecule to another.

31. Electric current does not flow easily through non-conductors.

32. Insulators are materials which have very few, if any, free electrons which may be moved with great difficulty from one atom or molecule to another.

33. Electrical resistors are materials which have only a few free electrons which may be moved from one atom or molecule to another.

34. Electrical switches and push bottons are used in circuits to make it possible to open and close them easily.

35. Electric current flows only through a closed circuit.

36. Common electrical circuits are classified as two types, parallel and series.

37. A short circuit usually occurs when suddenly a shorter path for electron flow is formed by a good conductor.

38. A short circuit develops in an electric appliance when the normal resistance in the appliance is suddenly decreased.

39. Fuses and circuit breakers are safety devices that prevent the overloading of an electrical circuit.

40. Resistance of a substance to the movement of the free electrons produces heat in the substance.

41. When a device offers resistance to the flow of electricity, it becomes heated.

42. A substance when conducting electricity tends to be warmer than its surroundings.

43. When an electric current flows through a material, the heat formed may cause the surrounding material to begin to burn.

44. The heating effects of an electric current cause house fuses to operate.

45. If a material resists the flow of large quantities of electricity, it may become incandescent and give off light.

46. In an incandescent electric light the filament is heated until it gives off light.

47. In fluorescent lighting the stream of electrons usually activates the mercury vapor which, in turn, causes the fluorescent lining of the tubes to emit visible light.

48. In fluorescent light tubes the quality of the desired light output determines the kind of fluorescent lining used.

49. In gas filled tubes used for lighting and signs, electrons passing through the gas heat the gas which causes it to glow.

50. A direct current of electrical energy can produce the same magnetic effect as a permanent magnet.

51. Current electricity is used in the operation of electromagnets.

52. Electromagnets are useful to man.

53. Electric current flowing through a conductor creates a magnetic field around that conductor.

54. An electromagnet may be made by passing a current through a coil of insulated wire that is wound around an iron core.

55. The strength of an electromagnet is determined by the amount of current and the number of turns of wire.

56. Telegraphs, electric bells, and electric motors use electromagnets to operate.

57. In a telegraph, the key is used to intermittantly interrupt the flow of current to the sounder or relay.

58. In an electric bell, buzzer, or chime the current activates an electromagnet which furnishes a mechanical force to produce the sound.

59. In an electric bell or buzzer the vibratory motion is produced by the alternate activation and inactivation of the electromagnet working against a spring.

60. An electric motor changes electrical energy into mechanical energy.

61. Electrical energy can be changed to heat, light, sound, magnetic energy, mechanical work, and chemical work.

62. Electric charges and current may be produced chemically, mechanically or photoelectrically.

63. Chemical energy is transformed into electrical energy by cells (voltaic cells) and batteries.

64. In dry cells, a chemical action may produce an electric current.

65. Dry cells furnish direct current.

66. When more than one voltaic cell is connected in series or parallel, they are usually referred to as a battery.

67. Mechanical power for the generation of electric current may be secured from many sources.

68. An electric generator changes mechanical energy into electrical energy.

69. A photoelectric cell is a device which changes light energy into electrical energy.

70. A galvanometer is a device used to detect weak electric currents.

71. A galvanometer may be modified to measure quantatively.

72. A modified galvanometer used to measure the rate of flow of electrons through a system is called an ammeter; one modified to measure electrical pressure is a voltmeter.

73. The electric unit for power is the watt.

74. The common unit for measuring consumed electrical power is the kilowatt-hour.

Winter and Spring

IV. The Universe

A. Earth

1. The earth is a planet of the solar system.
2. The earth's size is small compared to many other astronomical bodies in the universe.
3. The inside of the earth is hot enough to melt and vaporize most minerals.
4. The earth has a dense core of hot, "liquid," compressed rock, and a mantle of lighter rock.
5. The earth is surrounded by an atmosphere.
6. The air protects the earth from some of the dangerous radiations from the sun.
7. The earth moves in many ways.
8. The earth rotates regularly on its axis.
9. Our earth keeps turning from west to east.
10. The speed of rotation of an object tends to cause the object to bulge at the "equator".
11. The earth revolves around the sun.
12. The path of the earth around the sun is almost a circular orbit.
13. The position of the earth on its orbit determines the season.
14. The revolution of the earth around its orbit causes the seasons.
15. The year, the seasons and the day are measured in terms of repeating astronomical occurrences.
16. Devices to measure time are inaccurate.
17. The earth gets some light from the moon and stars.
18. Only about one-half of the earth may receive light from the sun at any one time.
19. The earth's atmosphere affects light.
20. The weight of an object depends upon the earth's gravitational pull.
21. The weight of objects is due to the attraction of the earth's gravitational field.
22. The gravitational field of the earth extends into space but decreases with the distance from the earth.

23. The gravity of the sun and the moon pulls on the water of the earth and causes the tides.

24. The movement of ocean vessels in harbors is often timed according to the tides.

B. Moon

1. The earth has only one natural satellite.

2. The moon is relatively near the earth.

3. The moon revolves about the earth as the earth revolves about the sun.

4. The composition of the moon appears to be similar to that of the earth.

5. The moon's surface appears to have craters and smoother lava flows (mare).

6. The gravitational effect of the earth keeps the moon in its path.

7. The moon is smaller than the major planets in our solar system.

8. The moon is larger than some bodies in the solar system.

9. The moon weighs less than any of the planets in the solar system.

10. The gravitational pull of the moon is less than that of the earth.

11. The force of gravity on the surface of the moon is less than the force of gravity on the surface of the earth.

12. The moon has little or no atmosphere.

13. Because of its small gravitational pull, the moon does not have an atmosphere.

14. There are no winds on the moon.

15. Only one side of the moon can ever be seen from the earth.

16. Only about one-half the moon's surface is toward the sun and is illuminated at any one time.

17. The only light which is received from the moon is that which is reflected from the sun.

18. As the moon moves around the earth, the side which is illuminated by the sun is not always completely visible to the earth.

19. The appearance of the moon changes during its cyclic movements around the earth each month.

20. The apparent shape of the moon which is seen at any one time is determined by the amount of the illuminated surface which can be seen.

21. The period of time required for the moon to go through a complete cycle of phases is definite.

22. In the complete cycle of the moon around the earth astronomers have chosen to indicate specific appearances as phases.

23. For easy reference the shapes of the moon at definite times each month have been given specific names of phases--first quarter, full moon.

24. When the phases of the moon are described in terms of first quarter, full, last quarter, and new moon, a definite appearance of the moon is understood.

25. The phases of the moon follow a regular order of new moon, first quarter, full moon, and last quarter.

26. The temperature on the surface of the moon varies greatly between the moon's day and night.

27. A lunar eclipse is caused by earth's shadow on the moon.

28. A solar eclipse occurs when the moon is in a straight line between the earth and the sun.

C. Sun

1. The sun is the center of the solar system.

2. The sun is much farther away from the earth than is the moon.

3. The sun is in the Milky Way galaxy.

4. The sun is near one boundary of the Milky Way galaxy.

5. The sun is many times larger than any planet of the solar system.

6. The sun is very old.

7. The life expectancy of the sun is very great according to estimates.

8. The sun is a "young" star.

9. The sun gives out light in all directions.

10. The sun is so bright the stars cannot be seen during the day.

11. The sunlight contains all colors.

12. Light from the sun is the source of the energy for the manufacturing of all foods and fibers.

13. The way the sunlight strikes the tilted earth causes the seasons.

14. Because of the tilt of the earth in relation to the sun, some parts of the world have summer while others have winter.

15. The total daily amount of energy received from the sun by the earth is the same throughout the year.

16. The amount of energy received during any one day at any one place on the earth depends upon the position of the earth on its axis.

17. The amount of energy absorbed at a specific location during a single day depends upon the directness of the sun's rays.

18. The sun's path across the sky is longer and higher in the summer than in winter.

19. The heat from the sun controls the temperature of the earth.

20. The innermost parts of the sun are hotter than its surface.

21. There are numerous, explosive flares on the sun (sunspots).

22. Sunspots seem to occur in cycles.

23. Sunspots create many changes on the earth's surface and in its surrounding magnetic field.

24. The auroras appear in the northern and southern skies simultaneously.

D. Solar System

1. The solar system consists of the sun and the astronomical bodies that revolve around it.

2. Those parts of the solar system which were first observed were those closest and most apparent on the earth.

3. Inadequate and inaccurate studies of the solar system led to many false conclusions about the solar system.

4. As methods of observation improved, more distant or less apparent objects in the solar system were studied.

5. Present-day observations are being conducted to obtain further knowledge about the solar system.

6. The sun is the center of the solar system.

7. The earth is one of nine known major planets that revolve around the sun.

8. Physical characteristics of the planets vary greatly in the solar system.

9. The physical environment varies greatly on the surface of each planet in the solar system.

10. The atmospheres of all planets are not alike.

11. The atmosphere of a planet is most dense near the surface.

12. Different planets have different lengths of "days" and "years" than the earth.

13. Many of the repetitive astronomical phenomena require time lapses greater than the length of a man's life.

14. Things near the "equator" on the surface of a rotating body move faster than things near the "poles".

15. Many of the planets in the solar system have one or more natural satellites.

16. All of the planets rotate on an axis and revolve around the sun.

17. All planets and most of their satellites appear to rotate in the same direction as the earth.

18. All known planets in the solar system revolve around the sun in their own definite orbits.

19. Asteroids or planetoids are smaller fragments of earth-like materials which usually are orbiting around the sun in the region between Mars and Jupiter.

20. Some of the larger and/or nearer planets may be observed at night with the unaided human eye.

21. The movement of planets in the sky as viewed from the earth does not seem to be in the same pattern as the movement of the stars.

22. Planets are not a part of constellations.

23. As far as is known, there are no other inhabited planets in our solar system.

24. The law of universal gravitation aids astronomers in predicting the courses of planets.

25. All planets affect one another because of the law of universal gravitation.

26. The greater the distance a planet is from the sun, the less energy it receives from the sun.

27. Planets reflect light from the sun.

28. Evidence indicates that men cannot live on other planets within the solar system.

29. Any life on other planets in the solar system must be different from life on earth because of a radically different environment.

30. Meteoroids are stoney and metallic particles revolving around the sun, either individually or in streams.

31. Meteors are sometimes called "shooting stars", even though they are not stars.

32. Meteoroids are a very small part of the solar system.

33. Meteors start burning some time after they come into the earth's atmosphere because they are heated by the friction of the air.

34. Meteoroids are too small to be separately visible by reflected sunlight and are seen only when they enter the earth's atmosphere and become luminous bodies (meteors).

35. Meteors are drifting chunks of rock in the solar system which have come near enough to the earth to be attracted by gravity and have begun to burn because of the friction of air.

36. The unburned portions of original meteors which reach the earth's surface are called meteorites.

37. Comets are not solid bodies, but are conglomerates of many different kinds of materials.

38. Comets follow regular paths in space.

39. The paths of comets may intersect the orbits of some planets.

40. The "tail" of a comet always points away from the sun.

41. Comets do not produce their own light.

42. An eclipse of any object occurs when the light from that object is prevented from coming to the earth.

43. A solar eclipse occurs when the moon cuts off the light coming to the earth from the sun.

44. Partial solar eclipses occur each year.

45. A total solar eclipse may be observed ohly rarely and then only from certain small areas of the earth, the position of which may be calculated by astronomers.

46. A lunar eclipse occurs when the earth cuts off the light from the sun to the moon.

E. Stars and galaxies

1. The universe is very big.

2. Early man observed and studied the stars.

3. Early observers drew many false conclusions.

4. The knowledge about the universe is constantly growing.

5. A telescope makes things appear closer.

6. More is learned about the universe as new instruments are developed or old instruments are improved.

7. A planetarium helps in locating stars and studying their apparent movement.

29. The apparent brightness of a star depends on its distance, size and temperature.

30. Some stars are much farther away from the earth than others.

31. Far away stars appear smaller.

32. The stars move in definite paths which are not easily observed.

33. Stars are moving very fast.

34. Stars are believed to be spherical due to the gravitational attraction

35. Stars do not appear to move with respect to each other because of great distances between them.

36. The apparent movement of stars in the night sky is due to the earth's rotation.

37. Near the poles, the stars appear to go around in concentric circles.

38. At the equator, the stars appear to move straight across the sky.

39. At any location on the earth there are many stars not visible because the earth obstructs the view.

40. "Shooting stars" are not stars at all, but are actually meteors.

41. Some "stars" may be parts of a solar system like the sun's solar system.

42. Some stars have burned out.

43. All stars are believed to be parts of galaxies.

44. Galaxies are huge collections or systems of stars.

45. The universe has many galaxies in it.

46. Different galaxies may have different shapes.

47. A few large-appearing stars are really galaxies.

48. Distant stars may actually be more than one star revolving around a common center (galaxies, binaries, etc.).

49. The solar system is part of the Milky Way galaxy (system) of stars.

50. The Milky Way galaxy has a rather definite size and shape.

51. The Milky Way galaxy is moving outward away from other galaxies.

52. The Milky Way galaxy as viewed from the earth does not show its true shape and size.

53. Most distances in the solar system and in the Milky Way galaxy are beyond comprehension.

54. Great distances in the universe are measured in terms of light years.

55. The light from most stars takes a long time to reach the earth.

56. The movements of astronomical bodies are influenced by the universal gravitation of all astronomical bodies.

57. The position of objects seen in the sky can be located in terms similar to latitude and longitude.

58. Small particles of solid material which are drifting in space are usually referred to as cosmic dust.

Spring

II. Living Things

A. Life and life processes

1. Non-living things cannot eat, breathe, or have young.
2. Substances which are neither animal nor vegetable in origin are said to belong to the mineral kingdom.
3. All living things have some characteristics in common.
4. Each living thing produces its own kind.
5. All living things are composed of cells.
6. The cell is the unit of structure of all living things.
7. Every living thing begins its life as one cell.
8. Living things increase in size as mature cells alternately divide and the newly formed cells grow to maturity.
9. Plants live and grow by adding new cells and renewing old cell content.
10. All living things have life cycles.
11. Some animals have several stages in their life cycles.
12. In order to complete the life cycle most green plants need air, sunlight, minerals and water from soil, and a favorable climate.
13. All living cells require oxygen to release energy for life.
14. Each living cell of an organism requires food.
15. All organisms must have a continuous supply of nutrients.
16. In order for a diet to be balanced there must be proper proportions of proteins, carbohydrates, fats, vitamins, minerals and water taken into the organism.
17. Some plants and animals live and grow on dead plants and animals (saprophytes).
18. Fungi are unable to make their own food.
19. Plants need carbon dioxide for the process of photosynthesis.
20. In carrying on photosynthesis, plants produce and release oxygen, which animals and plants use in the process of respiration.
21. The arrangement of the leaves on the stem of a plant usually enables the leaves to receive the maximum amount of sunlight.

22. Most stems support their leaves in such a way as to secure the most sunlight for the leaves.

23. Leaf cells containing a green substance called chlorophyll are able to make their own food.

24. All animals eat plants and/or other animals.

25. Animals depend upon green plants for food and oxygen.

26. Some animals shift their food habits with the changes in food supply.

27. The beak and feet of birds usually indicate what kind of food they eat and how they secure it.

28. Insects sometimes feed upon other animals.

29. Insects are food for birds, amphibians and reptiles.

30. Insects are considered essential to some plant and animal life.

31. Insects and certain other animals have changes of form and structure as they progress from egg to adult stage (metamorphosis).

32. The larval form of most insects consumes enormous amounts of food.

33. The pupal stage of an insect is not a resting stage but a very active one during which the worm-like larva changes into an adult insect.

34. Some insect larva spin a cocoon before going into the pupal stage.

35. Some insect larva go into the pupal stage without spinning a cocoon.

36. From the cocoon or pupal stage the adult insect emerges.

37. Insects shed their exoskeleton many times during their development.

38. Mammals are born alive.

39. The female mammal produces milk for her young.

40. The young mammal takes milk from the mother.

41. There are different ways in which mammals locate their food.

42. Animals secure oxygen in various ways.

43. During respiration, oxygen enters living organisms.

44. During respiration, carbon dioxide is given off by living organisms.

45. Plants require oxygen for respiration.

46. Many plants respire through tiny openings called stomata.

47. In vertebrate animals, the respiratory system secures the oxygen and delivers it to their internal fluids.

48. Most fish and young amphibians secure their needed oxygen by means of gills.

49. Mammals, birds, reptiles and some adult amphibia breathe air by means of lungs.

50. Many lower animals secure needed oxygen through their outside covering.

51. Lungs and gills are organs of excretion for carbon dioxide and water.

52. Solid, liquid and gaseous wastes are formed by organisms.

53. Great amounts of water are given off into the air by plants during normal growth.

54. Water is the most important solvent in living organisms.

55. Water is absorbed into the transportation system of a higher plant through its root system.

56. Most of the absorption of water and dissolved minerals into plants takes place through the root hairs.

57. Most plants absorb necessary water and minerals through the roots.

58. All living things have internal motion (circulation).

59. Circulation in plants and animals carries food and oxygen to all parts of the body.

60. The circulatory system transports simple foods to all living cells.

61. The heart is a very strong muscle which pumps blood to all parts of the organism.

62. Blood moves throughout the organism.

63. Blood moves in the organism through definite pathways called arteries, veins and capillaries.

64. Flowers are the reproductive structures of the seed-producing plant.

65. The essential structures of a flower's reproductive system are the pistil and stamen.

66. Seeds may form in the part of the flower called the pistil, and pollen is produced by the stamen of a flower.

67. Wind and insects often aid pollination.

68. Man has changed the characteristics of some plants by cross-pollination.

69. Man may propagate some varieties of plants by grafting or budding.

70. Some new plants grow from roots, stems, or leaves.

71. The embryonic plant in a seed usually is dependent on the surrounding material for nourishment and protection.

72. Some species of fungi are able to reproduce through the formation of spores.

73. Many animals have special structures called sense organs.

74. Some animals see better than others.

75. The eye is a sense organ for seeing.

76. The ear is a sense organ for hearing.

77. The tongue contains the sense organs for tasting.

78. The skin contains the sense organs for touching.

79. The nose contains the sense organs for detecting odors.

80. Hunger and fear are stimuli which cause some organisms to react.

81. Sensations such as hunger cause internal responses in some animals.

82. Many organisms react to chemical stimuli.

83. Organisms which are able to sense unfavorable conditions tend to seek optimum conditions.

84. Some pets can be trained because they have the ability to sense and respond.

B. Classification

1. The use of animals as beasts of burden and/or for transportation continues in some parts of the world.

2. Animals live on the earth, in the earth and in water.

3. Some animals have only one cell and others have many cells.

4. Animals may have adaptations for the type of food they eat.

5. The body structure of an animal may determine its habitat.

6. Animals live singly or in groups.

7. All animals may be classified into two groups: those with backbones and those without backbones.

8. Animals which are classified as insects have three pairs of legs; spiders, ticks and mites have four pairs of legs.

9. The larva or worm-like form of insects can be recognized by the three pairs of jointed legs near the head.

10. When some kinds of insects hatch, they (nymphs) resemble the parents, while other newly-hatched insects are worm-like (larva) and do not resemble either parent.

11. The five major groups of animals with backbones are fish, amphibia, reptiles, mammals, and birds.

12. Some animals breathe air by means of lungs.

13. Some aquatic animals take oxygen into their blood and release carbon dioxide by means of gills.

14. Cold-blooded animals have no internal means of controlling their body.

15. Healthy, warm-blooded animals usually are able to control their body temperatures by internal means.

16. Mammals are usually covered with fur or hair.

17. Mammals differ in the food they eat.

18. There are different ways in which mammals locate their food.

19. The female mammal is the only animal which produces milk for her young.

20. All birds cannot walk, swim and fly.

21. The beak and feet of birds usually indicate what kind of food they eat and how they secure it.

22. Some water animals cannot move about freely.

23. Although only a very few species of fish build nests, most fish lay eggs in shallow water.

24. Animals give varying amounts of care to young.

25. The young of some animals receive no care from the parent.

26. Animals which give birth to living young usually give the young much care.

27. Some living things go through a period of dormancy during extreme cold (hibernate) or heat (estivate).

28. The wounds and stings of some animals are annoying, but rarely serious; e.g., bees, spiders, snakes.

29. Certain insects and arachnids annoy and irritate man.

30. Structural differences are usually used to differentiate one plant from another.

31. Plants may be grouped according to the structures of their roots, stems, leaves, flowers, and fruits.

32. Green plants, in the presence of light energy, can remove carbon dioxide and water from the environment and synthesize simple foods from them.

33. Fungi are plants which cannot make their own food.

34. Algae are the simplest green plants.

35. Leaves have different kinds of cells.

36. Trees are classified as coniferous and deciduous.

37. Most plants are not able to move from place to place without aid.

38. All living things have some characteristics in common.

39. Non-living things cannot eat, breathe, or have young.

40. Plants and animals are usually classified and grouped on the basis of similarities and differences in body structures.

41. There are many popular methods of classifying organisms into groups.

42. Different living things are grouped according to the different environments, or "communities," in which they live.

43. Plants of some kind grow on almost every part of the earth, even the polar regions.

44. Some plants are adapted to living under water.

45. Plants may be grouped according to whether they live in sunny or shady environments.

46. Some plants are adapted to live in shady, cool areas.

47. Some plants and animals live and grow on other plants or animals.

48. Some organisms derive their nourishment from other organisms (parasites).

49. Some plants and animals live and grow on dead plants and animals (saprophytes).

50. Fungi must secure their food from other plants or animals.

51. No valid tests are known by which non-poisonous mushrooms can be distinguished from poisonous ones.

52. Scavengers remove dead plant and animal materials.

E. Human body

1. Children's bodies change as they grow.

2. Man needs food, air, water, vitamins, and minerals.

3. In order for a diet to be balanced there must be proper proportions of proteins, carbohydrates, fats, vitamins, minerals and water taken into the body.

4. Proper amounts of certain minerals and proteins are necessary in the daily diet of healthy animals.

5. Ultraviolet radiations cause our skins to sunburn.

6. Sunlight usually includes infrared rays which furnish heat and ultraviolet rays which cause sunburn.

7. Endurable quantities of ultraviolet light usually stimulate the production of melanin (brown pigment which is called a "tan") in the human skin.

8. The type of clothing worn by an individual should depend on the temperature of the immediate environment.

9. Perspiration as it evaporates cools the body.

10. Healthy, warm-blooded animals usually are able to control their body temperatures by internal means.

11. Blood moves in the body through definite pathways called arteries, veins and capillaries.

12. Different kinds of teeth have different functions.

13. The different kinds of permanent teeth have different shapes.

14. Different types of teeth are suited for food cutting, tearing and grinding.

15. Chewing food thoroughly enables the stomach to disperse and mix foods more effectively.

16. To prepare foods for animal digestion the food must be ground into small particles and mixed with certain body fluids.

17. Brushing the teeth thoroughly removes the food particles which supply nutrients for some bacterial growth.

18. The mouth furnishes ideal conditions for the development of most bacteria.

19. Covering the mouth and nose when sneezing helps control the number of disease germs in the air.

20. The hairs and moist lining of the nose help keep disease germs from entering human bodies.

21. Many of the diseases of man are caused by minute unicellular organisms (bacteria).

22. Proper care of wounds and stings helps avoid growth of bacteria.

23. Some plants and animals transmit diseases.

24. Some plants must be avoided because they are poisonous and produce immediate or delayed irritation.

25. Some plants and/or their products may cause internal or external toxic reactions in man.

RESOURCE UNITS

HEAT AND INFRARED RADIATION

A Partial Unit

Grade 5, Science

Some of the learning experiences listed were suggested by second year teachers at a fifth grade science inservice meeting on March 10, 1964. Others were taken from the sources listed. Dr. J. Hervey Shutts and Joseph L. Premo conducted the workshop sessions and reviewed and edited the results.

The concepts and experiences listed here are not necessarily presented in the order in which you may wish to teach them. It is hoped that this partial unit will serve as a resource, and that ideas presented here will suggest other experiences appropriate for your group of boys and girls.

CAUTION: Many experiences listed involve the use of fire or electrical heating units. These should be closely supervised by you, the teacher. Safety precautions should be observed and emphasized with boys and girls. For example, when a flame is used in a classroom, a fire extinguisher should be in the room ready for use. One of the outcomes of the unit might well be the establishing of safety habits when handling potentially dangerous equipment.

See handbook: Procedures for the Program of Fire Safety in the Minneapolis Public Schools. p. 7, p. 9

SCIENTIFIC APPROACH TO PROBLEM SOLVING

1. Observation - first-hand experiences and observations.
2. Definition of PROBLEM - ask questions, choose one for investigation.
3. Results of other investigators - read about problem, discuss it with interested friends and resource people, examine the written material.
4. Possible solutions - list all possible guesses.
5. Choosing the best solution (HYPOTHESIS) - pick the "best guess."
6. Testing the hypothesis - planning and carrying out EXPERIMENTS to determine its truth.
7. CONCLUSION of accepting or rejecting hypothesis - draw conclusion from experiments to determine acceptance or rejection of "best guess."
8. More extensive testing of hypothesis - experiment further to determine if hypothesis always holds true.
9. Stating the THEORY and publishing results - restate the hypothesis in light of the above experimentation, publish in professional journal.
10. Finding mathematical proof - do any measuring and mathematical calculations to develop proof of theory.
11. Statement of LAW or PRINCIPLE - if no one can find a mistake in the mathematical proof or develop a contrary proof, the theory becomes a law or principle.

Concept 1. Warm objects are continually radiating energy (radiation).

Previous to teaching this concept, define heat as one form of energy.

a. Define "warm objects"

(1) Feel objects in room, e.g., stone, wood, metal, rubber, plastic, etc.

Place materials in sunlight and/or in hot water and feel again.

Cool materials by placing in ice water and feel again.

Discuss observations: some objects can be heated or cooled by changing their surroundings, and we can detect these changes.

There may be disagreement among individuals, i.e., an object which feels "hot" to one child may feel "warm" to another. Terms such as "warm," "cold," "hot" are relative.

(2) Fill three containers with water of various temperature: one ice cold, one lukewarm, one relatively hot. Have children place hands first in cold and lukewarm, then in lukewarm and hot water. Does lukewarm water feel the same in both cases? Again, children make generalization that warmth is relative.

(3) Have children place hands in cold water for at least one minute and then feel objects. Do the same with hot water. Note differences in their observations.

(4) It may be helpful to note words used to describe warmth: cold, cool, lukewarm, tepid, warm, hot, etc. Note common uses of these terms, e.g., in weather reports, recipes, etc.

(5) Discuss need for measuring temperatures quantitatively, with thermometers.

b. Discuss thermometers as instruments for measuring.

(1) Various kinds of thermometers may be brought and their uses discussed.

- indoor thermometer to measure air temperature
- outdoor thermometer to measure air temperature
- clinical thermometer to measure body temperature
- candy (cooking) thermometer to measure temperature of hot liquids
- meat thermometer to measure internal temperature of roasting meat
- etc.

(2) Compare construction and uses of thermometers. Find out why a clinical thermometer does not register air temperature when it is removed from the mouth.

Hone, A Sourcebook for Elementary Science p. 293

(3) If children have made their own thermometer and calibrated it (in a weather unit), this will be more meaningful.

(Directions for making a simple thermometer are found in many science books, e.g.,
Hone, A Sourcebook for Elementary Science, p.98
Blough, Elementary School Science, pp. 413-414)

(4) Examine a mercury thermometer. Discuss how mercury expands and contracts, causing it to rise and fall in the small tube.

(5) Discuss use of various liquids in thermometers - are there advantages and disadvantages in each?

(6) Discuss the importance of the calibration of thermometers. Place a thermometer in a glass jar containing ice and water. Stir. Record temperature at 30 second intervals stirring each time, until temperature no longer decreases. This temperature is the freezing point of water, 32° on Fahrenheit scale, 0° on Centigrade(Celsius).

Put a thermometer in a pan of water and place over flame or hot plate. Heat water. At one minute intervals stir water and record temperature until there is no further increase in temperature. This temperature is the boiling point of water, 212° on the Fahrenheit scale, 100° on Centigrade (Celsius)

(Caution should be used in putting a cold thermometer into hot water.)

c. Discuss ways in which heat is transferred, e.g., radiation, convection, and conduction. (See also concepts 7, 8)

Blough, *Elementary School Science*, p. 402-403

(1) Find examples of each type of heat transfer, e.g.,

- radiation - sun, fireplace, charcoal broiler, toaster
- convection - radiators, gravity type furnaces, hot water heaters, boiling liquids
- conduction - cooking foods by frying, ironing clothes

(2) Transfer of heat by radiation may be felt by holding a hand a few inches below a lighted electric light. Warmth can be felt and may be measured with a thermometer. If a book is held between the light bulb and the hand, there is no feeling of heat.

(Note: if hand is held above bulb, some heat is also transmitted by convection.)

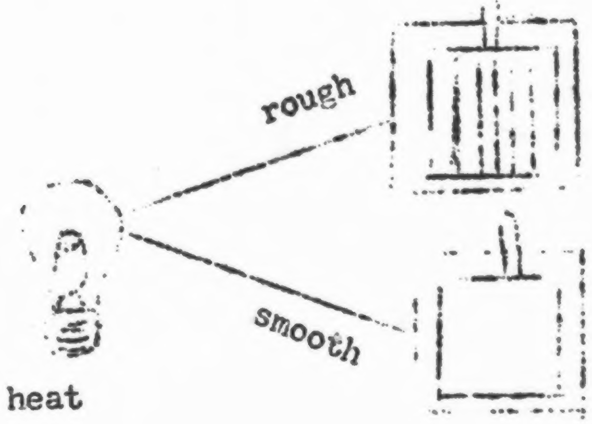
Concept 2. Increasing the surface area of a heated object usually increases the rate of heat dissipation.

a. Pour equal measured quantities of hot water into two pans (such as a 4" x 4" x 2" and a 9" x 12" x 2") or two cans (such as a coffee can with a wide mouth and an orange juice can with a narrow mouth). Place thermometer in each container. Record temperature in each container at 5 minute intervals and compare.

For more accurate results, cans may be wrapped with insulating material, so that heat dissipation is mainly confined to surface of water.

Concept 3. Rough surfaces are good absorbers and radiators of heat.

a. Use white corrugated paper as a rough surface, white construction paper as a smooth surface. Staple a piece of each to chipboard and stand them side by side. Place a thermometer between the corrugated paper and and chipboard and another thermometer between the construction paper and chipboard. Note and record temperature on each thermometer. Place a light bulb or hot plate facing the white surfaces and equidistant from both. Turn on heat. Record temperatures at 30-second intervals. Compare rise in temperatures.



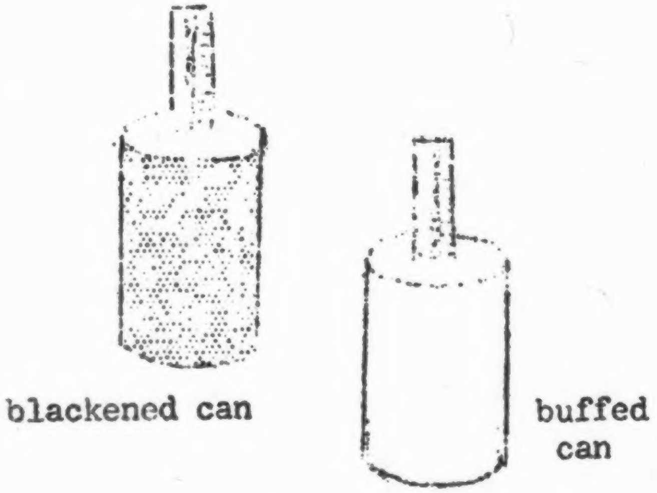
b. Encourage boys and girls to make observations of possible applications of this concept in everyday life.

Concept 4. Dark-colored substances absorb heat more readily than light-colored subtances.

Concept 5. Dark-colored substances give off heat more readily than light-colored substances.

a. Same experiment as 3a, but using black and white construction paper as materials. Place thermometers behind paper to measure absorption, in front of paper and facing paper to check radiation. Record temperatures at 30-second intervals and compare.

b. Take 2 large fruit juice cans (46 oz.) whose covers are intact except for holes punched in top. Buff one to a high polish with metal polish. Blacken the other with candle soot or paint dull black. Insert thermometers in each, and seal holes in top with adhesive or friction tape. Place electric heating unit equidistant from cans - note temperature changes every 5 minutes. Record temperatures and compare.



Hone, A Sourcebook for Elementary Science, p. 332
Blough, Elementary School Science, p. 417

c. Place one thermometer on a black cloth and another on a white cloth. Place in sunlight. Record temperatures. Wait 15 minutes and read temperatures again. Record and compare temperatures.

d. Apply knowledge to practical situations, e.g., color of clothing which should be worn in warm weather.

Hone, A Sourcebook for Elementary Science, p. 321

Does the color of a house affect its temperature?
Does the color of a car's top affect the temperature inside the car?

e. Encourage boys and girls to look in newspapers and magazines for articles and advertisements which make use of this knowledge.

Concept 6. Objects exposed to the sun usually cool when the sun no longer shines on them.

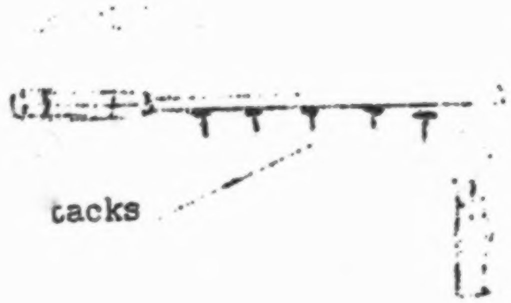
a. Place a pan of water in direct sunlight. Take temperature readings every 15 minutes and record. Continue to take temperature readings when sun no longer shines on pan.

b. In the winter observe ice melting on sidewalk when sun shines on it, refreezing when sun no longer shines on it.

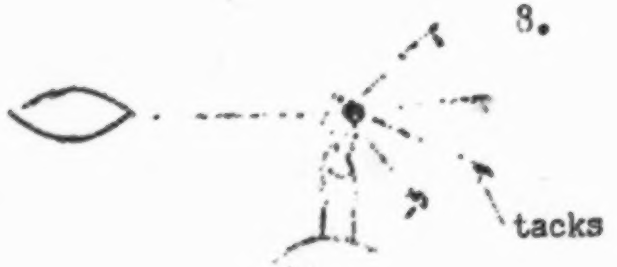
c. Place hand in sunlight until warmth can be felt. Move into shade. Does it feel cooler?

Concept 7. Heat travels through various materials (conduction).

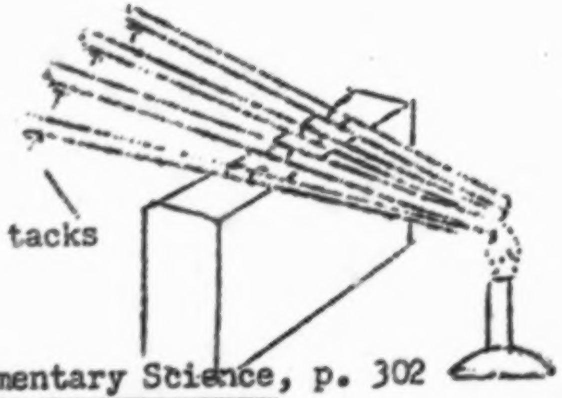
a. Obtain a round brass curtain rod, about 12-15" long. Wrap one end with paper and fasten with rubber bands to form a handle. Attach tacks to the rod with paraffin from a burning candle - place them at intervals of about 1". Hold the free end of the rod in the flame of a Bunsen burner, candle, or alcohol lamp. As heat travels along the rod, the paraffin melts and tacks fall off.



Hone, A Sourcebook for Elementary Science, p. 302



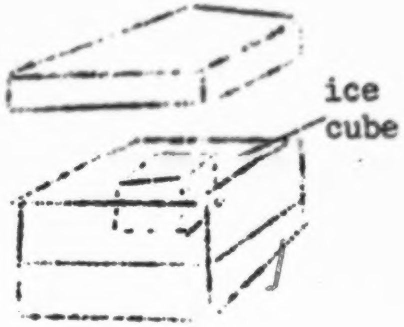
c. Attach a tack with candle paraffin to each prong of a conductometer. (A conductometer is a fork-like piece of equipment, with prongs made of various metals, usually one each of aluminum, copper, brass, and steel.) Apply heat at the point where prongs meet, and observe the order in which tacks fall off due to the melting of the paraffin.



d. The same experiment as 7c above may be performed using 12" rods of various materials such as copper, brass, iron, glass, steel, etc. These are attached to a wooden block or box so that the ends meet. At the outer end of each rod, attach a tack with a drop of melted paraffin. Apply heat where the ends of the rods meet, and note order in which tacks fall off.

Hone, A Sourcebook for Elementary Science, p. 302

e. Illustrations of the reverse, i.e., good insulating materials may also be discussed.



(1) Wrap ice cubes in various insulating materials and check after 2 or 3 hours. Scrap or sample materials may be obtained from lumber yards or builders. Use materials such as aluminum foil, expanded polystyrene, rock wool, etc. In shaped materials which cannot be easily wrapped around ice cubes, a hole the size of an ice cube may be cut in one block. Two other solid blocks then serve as a base and cover.

See also:
Hone, A Sourcebook for Elementary Science, pp. 329-331

(2) Place ice cubes in drinking tumblers of glass, insulated plastic, aluminum, and polystyrene. (Tumblers should be approximately the same size.) Note rate of melting.

Measure with graduated cylinder (baby nursing bottle) the amount of water collected from the melting ice cube.

or

Measure by weight (with scale) the amount of water collected from the melting ice cube. Final time = when one ice cube has completely melted.

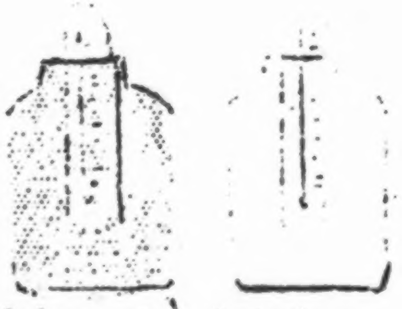
Record:

Container	Weight of Ice at Start*	Weight of Each Time Intervals 1	2	3	4	5	Final Time
Aluminum							
Glass							
Plastic							
Paper							
Styrene							
etc.							

*Ice cubes might be standardized by pouring a measured (equal) amount of water into individual plastic ice cube forms, then freezing.

(3) Put equal amounts of hot water in two jars of the same size. Make aluminum foil covers, insert thermometers. Wrap one of the jars in insulating material. Read thermometers every 10 minutes.

Record temperature of water in each jar and compare.



f. Note examples of uses of conductors and insulators, e.g., materials used in cooking utensils, materials used for handles of cooking utensils, use of pot holders, etc.

g. Find out how the design of a thermos (vacuum) bottle makes it possible to keep liquids either hot or cold.

Hone, A Sourcebook for Elementary Science, pp. 404-405

h. Why is packaged ice cream sometimes placed in bags of aluminum foil?

i. Find out where insulating material is needed in houses.

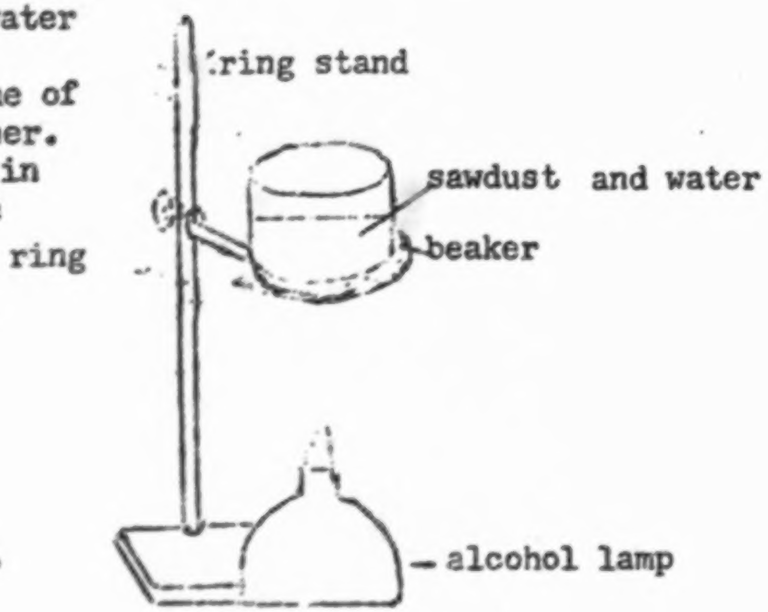
Blough, Elementary School Science, pp. 404-405

Concept 8. Air near hot objects becomes heated and transfers the heat elsewhere (convection).

a. Review from weather unit: heated air rises.

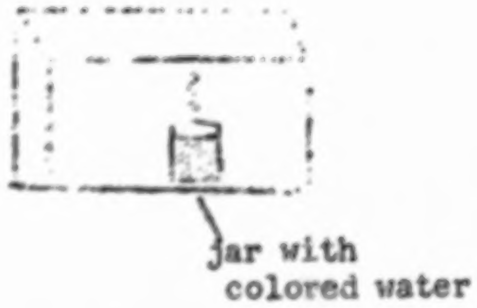
b. Narrow tissue paper strips may be held in various places in room. See if you can detect and diagram convection currents. Fasten paper strips to long wooden dowels to check near ceiling.

c. To observe convection currents place a pyrex pan or pyrex beaker (400ml) on a ring stand. Fill 3/4 full of very cold water. Add 2 teaspoons of sawdust. (Do not use pencil shavings from pencil sharpener, they do not absorb water and will float on the top of the water.) Allow the sawdust and water to stand for about 5 minutes. Some of the sawdust must settle to the bottom of the container. Place an alcohol burner under the beaker - directly in the center works well. Light the burner and observe the pattern of movement of the sawdust and water. Careful placement of two thermometers (one in the upward moving sawdust near the center and the other near the outside where the sawdust is going down) will show a very slight degree of difference in the temperatures of the water at those points. CAUTION: DO NOT ALLOW THE THERMOMETERS TO TOUCH THE BOTTOM OF THE CONTAINER, CONDUCTION THRU THE GLASS TO THE THERMOMETER COULD HARM THE THERMOMETER.



See also:
Hone, A Sourcebook for Elementary Science, p. 334
Blough, Elementary School Science, p. 418

d. Fill a small container (baby food jar) to the very top with very hot colored water. Place the cover on loosely. Carefully place this container into a large jar (battery jar, pickle jar, or aquarium) of very cold water. Carefully remove cover of small jar and observe what happens to the colored water.

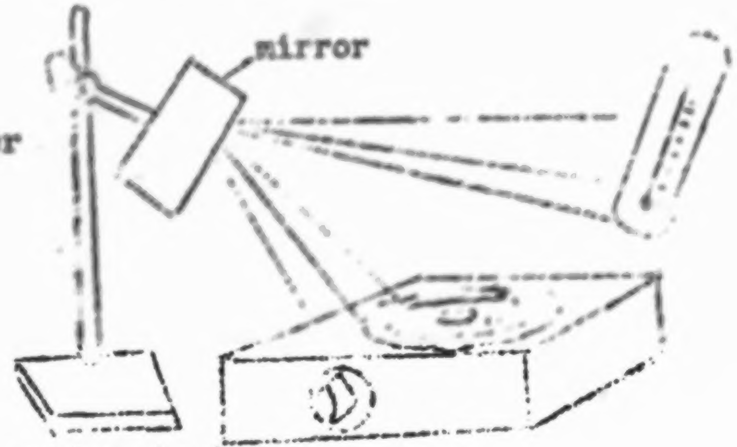


e. Fill a small container (baby food jar) to the very top with very cold colored water. Place the cover on loosely. Fill a larger container (battery jar, pickle jar, or aquarium) with warm water. Invert the small jar at the surface of the water of the larger jar and carefully remove the cover. Watch the movement of the colored water.

See also:
Hone, A Sourcebook for Elementary Science, pp. 305-307

Concept 9. Heat may be directed by reflection.

a. Mount a mirror or piece of aluminum foil at an angle over a hot plate. Nearby hang and observe a thermometer and record temperatures at one minute intervals.



b. Can you apply this concept to justify the lining of an outdoor barbecue with aluminum foil?

Concept 10. Evaporation of water results in a cooling effect.

a. Using a ball of cotton, place some water on the back of a child's hand. Fan his hand and notice the feeling of coolness. Repeat using rubbing alcohol. Compare results.

b. Record the temperature as measured by two similar thermometers. Wrap the bulb of one of the thermometers with wet cotton. Place the two thermometers side by side and fan them for some time. Record their final temperatures. The final temperature will be reached when the wet bulb thermometer registers a constant temperature.

c. Repeat 10b above using cotton wet with alcohol instead of water. Compare the results of 10b and 10c. Why is there a difference?

d. Devise some experiments with wet swimming suits or wet clothes in spring, summer, and fall.

Concept 11. Increasing the temperature usually increases the rate of evaporation.

a. Place a measured amount of water in each of two containers. The amounts of water must be the same and the container must be the same size and shape. Measure and record the temperature* of the water in each container. Place one container in the sunlight and the other in the shade. Measure and record the temperature* of the water in each container every 15 minutes. Measure and record the amount of water evaporated at some appropriate time. (This time will depend upon the amount of water used and the shape of the container.)

b. Using the same materials and procedure as outlined in 11a above, place one container on a hot plate set at its lowest setting. Measure and record the temperatures* and amount of water evaporated as above. CAUTION: DO NOT ALLOW THE BULB OF THE THERMOMETER TO COME INTO CONTACT WITH THE BOTTOM OF THE CONTAINER. CONDUCTION OF HEAT THRU THE BOTTOM OF THE CONTAINER COULD HARM THE THERMOMETER.

Concept 12. Increasing the rate of air movement usually increases the rate of evaporation.

a. Wet two spots (same size) on the chalkboard. Fan one spot and observe the rates of drying of both spots.

---

*When taking the temperature of the water it is important that the water be stirred and then the temperature taken.

b. Place an equal and measured amount of water in two pans of the same size. Place one pan in front of an electric fan. Observe, record, and compare rates of evaporation.

c. How does a clothes dryer provide for air movement?

Concept 13. Increasing the surface area usually increases the rate of evaporation.

a. Place an equal and measured amount of water into 2 (preferably more than 2) containers of different sizes and shapes. Try and use containers that have as different surface areas as you can find, for example, test tube and cookie sheet. Place all the containers in similar situations in terms of heat, temperature, and air flow. Record the amount of water used at the start and the time of beginning. Record the final time (when one of the containers is dry). Measure and record the amount of water left in each container and its surface area. Draw some conclusions about the relationship of surface area to rate of evaporation.

b. Wet two rags of equal size. Leave one crumpled up, spread the other flat. Observe which dries faster.

Using concepts 11, 12, and 13, what are the optimum conditions for drying clothes?

Concept 14. Increasing ventilation or circulation of air usually increases the evaporation of moisture from the skin.

a. Wet both hands. Hold one in front of a fan and observe the rate of drying.

b. Note construction of clothing designed to increase circulation of air, e.g., vents in plastic raincoats.

c. Relate to experiences of boys and girls, e.g., how it feels to run or to ride in a speedboat dressed in a wet bathing suit.

Concept 15. Devices which produce large quantities of heat must be equipped with controls.

a. Identify devices producing quantities of heat, e.g., furnaces, ovens, water heaters, etc.

b. Define "controls" as devices which limit or govern the maximum temperature.

c. Find examples of appliances with temperature controls - ovens, irons, electric fry-pans, etc.

d. Take the cover off a home thermostat. Hold over source of heat to observe action. An oven thermometer may be used to demonstrate this principle.

Hone, A Sourcebook for Elementary Science, p. 292

e. Construct a thermostat with a bimetallic strip.

Hone, A Sourcebook for Elementary Science, p. 289

f. Boilers in schools have pressure controls to limit pounds of pressure produced. In schoolrooms, the "Univent" distributes the heat; it also has valves and dials (controls). Both can be demonstrated to children. The teacher should go through the demonstration with the engineer first.

Concept 16. Foods are preserved by various cooling and freezing processes.

a. Place equal and measured amounts of milk in two containers. Place one in refrigerator, leave other at room temperature. Observe each milk container each day. Observe and record when milk is sour in each container.

b. List kinds of foods which may be stored at room temperature, which need refrigeration, and which are frozen.

Is packaging a factor?

c. Some foods are usually not frozen, e.g., tomatoes, watermelon, etc. Do these foods have some common characteristics which might account for this?

d. Foods which are frozen for storage are usually packaged tightly and sealed. Non-porous materials are often used. Find out why this is necessary.

e. Study history of food preservation. Correlate with social studies, e.g., problems of food storage faced by early settlers in the United States.

Concept 17. Light energy, when it is absorbed, may change into heat.

Find out how cold frames illustrate this concept.

Concept 18. Some of the energy of former sunlight is stored in our fossil fuels.

a. Find out how coal and oil are formed.

b. Find out why scientists are looking for substitutes for coal and oil.

Concept 19. Man is using solar energy for cooking and heating.

a. Look for experimental uses in periodical literature.

b. Find examples of architecture which makes use of winter sunshine. Note how wide eaves and louvers are used to shade windows in summer.

Blough, Elementary School Science, p. 408-410

Concept 20. Temperatures can be measured by various instruments.

a. Collect samples of various kinds of thermometers (concept 1).

b. Some boys and girls may be aware of other instruments which are used by scientist and technicians to measure temperature, e.g., thermocouples, spectroscope. It is not suggested that they understand how these work, or even know the names.

Concept 21. Temperatures may be expressed in various temperature scales.

a. Compare Fahrenheit and Centrigrade (Celsius) scales (see concept 1).

b. Find out about the Absolute scale, the Kelvin.

2

Sources for teachers:

Blough, Glenn O. and Campbell, Marjorie H., *Making and Using Classroom Science Materials in the Elementary School*. Dryden, 1954. pp. 168-174

Blough, Glenn O., Schwarts, Julius, and Huggett, Albert J., *Elementary School Science and How to Teach It*. Dryden, 1958. pp. 224-225, 397-421.

Hone, Elizabeth B., Joseph, Alexander, Victor, Edward, and Brandwein, Paul F., *A Sourcebook for Elementary Science*. Harcourt, Brace, and World, 1962. pp. 285-313, 320-322, 329-336.

Mary Jane Higley, Helping Teacher
Grade 5
Miss Mildred A. Carlson, Consultant
in Elementary Curriculum

MAC:MJH:dhb
May 26, 1964

A RESOURCE UNIT

IV. THE UNIVERSE

A. EARTH, B. MOON, C. SUN, D. SOLAR SYSTEM, E. STARS AND GALAXIES

TO BE TAUGHT IN
GRADE FIVE

To be included in the Grade Five Supplement of the
Reorganized Science Curriculum

Minneapolis Public Schools
Science Department
8-24-64

TABLE OF CONTENTS

I. Overview ix

II. Concepts included in the unit 1

III. Teacher preparation activities 11

IV. Teacher procedures

A. Introduction to the Teaching Procedures 12

B. Technique I - An activities approach 12

C. Technique II - Class study approach 13

D. Technique III - An individual or group study approach 14

Bibliography for Technique III 16

Visual Aids for Technique III 22

V. Pupil learning experiences

A. Comparing the sizes of the planets and the sun, and the distances between them 23

B. Picturing star groups 27

C. Making a planetarium 30

D. Demonstrating the phases of the moon 31

E. Observing the surface of the moon................ 33

F. Studying meteors 34

G. Calculating the number of miles in a light year 35

H. Demonstrating the effects of rotation 36

I. Learning why different stars and different groups of stars are seen at different times of the year 37

J. Studying the forces acting on objects 38

TABLE OF CONTENTS (continued)

K. Showing the earth receives little of the sun's total light and heat 39

L. Demonstrating an eclipse of the sun or moon 40

M. Constructing a sun dial 41

VI. Evaluation

A. Evaluation of the individual child's learning ... 43

B. Evaluation of the teacher's success 44

VII. Bibliography

A. Textbooks 46

B. Reference books for pupils 48

C. General reference for the teacher 50

D. Professional literature for the teacher 50

VIII. Visual aids

A. Instructional Films - (student-teacher).......... 51

B. Filmstrips - (student-teacher) ,................ 51

C. Tapes, scripts, or records 52

D. Charts 53

1. Some Astronomical Facts and Approximations for Teaching 54

2. Twenty Stars of the First Magnitude 55

3. Moon Changes 56

IX. Suggested Supplies and Equipment 57

X. Appendices 58

Appendix A 59

Appendix B 60

Appendix C 61

For discussion purposes only

I. Overview

This resource unit contains concepts about the universe as we see it from the earth. Included in the unit are concepts about our solar system, our galaxy, and other galaxies. It does not include concepts on rocketry, space travel, or geology.

In this resource unit, teaching methodology and plans of procedure are closely interwoven. Although three distinct procedures for teaching this unit are presented, the classroom teacher may wish to combine these, using a different procedure at different stages in the development of the unit. Technique I, an activities approach, suggests a demonstration which the teacher can use to motivate the children for the study of the universe. The unit then is developed through a series of activities, each of which the teacher or a group of children prepares and demonstrates to the class. Technique II, a class project approach, assumes that the class formulates a list of questions and then acts as a committee of the whole to learn the answers to the questions. Technique III, an individual or small group study approach, uses a small committee of children who act as "experts" to direct the study. Each child selects one topic from a list of topics. The entire class is informed about each topic in a report prepared by a child or a small group.

In an effort to make this resource unit valuable to the classroom teacher, sections containing some suggestions for teacher preparation, pupil learning experiences, evaluation of the unit, and teacher and pupil bibliographies of books and visual aids are included.

The classroom teacher is urged to modify the suggestions in this resource unit as he prepares his teaching unit in order to fit it to the needs of his own, specific group of children. This resource unit does not contain direct suggestions for teaching of the concepts. Therefore, as the unit progresses, the classroom teacher should periodically check the list of concepts included in the unit to be sure that none of the concepts is omitted.

II. Concepts included in the unit

IV. The Universe.

A. Earth.

1. The earth is a planet of the solar system.
2. The earth's size is small compared to many other astronomical bodies in the universe.
3. The inside of the earth is hot enough to melt and vaporize most minerals.
4. The earth has a dense core of hot, "liquid", compressed rock; and a mantle of lighter rock.
5. The earth is surrounded by an atmosphere.
6. The air protects the earth from some of the dangerous radiations from the sun.
7. The earth moves in many ways.
8. The earth rotates regularly on its axis.
9. Our earth keeps turning from west to east.
10. The speed of rotation of an object tends to cause the object to bulge at the "equator".
11. The earth revolves around the sun.
12. The path of the earth around the sun is almost a circular orbit.
13. The position of the earth on its orbit determines the season.
14. The revolution of the earth around its orbit causes the seasons.
15. The year, the seasons and the day are measured in terms of repeating astronomical occurrences.
16. Devices to measure time are inaccurate.
17. The earth gets some light from the moon and stars.
18. Only about one-half of the earth may receive light from the sun at any one time.
19. The earth's atmosphere affects light.

20. The weight of an object depends upon the earth's gravitational pull.

21. The weight of objects is due to the attraction of the earth's gravitational field.

22. The gravitational field of the earth extends into space but decreases with the distance from the earth.

23. The gravity of the sun and the moon pulls on the water of the earth and causes the tides.

24. The movement of ocean vessels in harbors is often timed according to the tides.

B. Moon.

1. The earth has only one natural satellite.

2. The moon is relatively near the earth.

3. The moon revolves about the earth as the earth revolves about the sun.

4. The composition of the moon appears to be similar to that of the earth.

5. The moon's surface appears to have craters and smoother lava flows (mare).

6. The gravitational effect of the earth keeps the moon in its path.

7. The moon is smaller than the major planets in our solar system.

8. The moon is larger than some bodies in the solar system.

9. The moon weighs less than any of the planets in the solar system.

10. The gravitational pull of the moon is less than that of the earth.

11. The force of gravity on the surface of the moon is less than the force of gravity on the surface of the earth.

12. The moon has little or no atmosphere.

13. Because of its small gravitational pull, the moon does not have an atmosphere.

14. There are no winds on the moon.

15. Only one side of the moon can ever be seen from the earth.

16. Only about one-half the moon's surface is toward the sun and is illuminated at any one time.

17. The only light which is received from the moon is that which is reflected from the sun.

18. As the moon moves around the earth, the side which is illuminated by the sun is not always completely visible to the earth.

19. The appearance of the moon changes during its cyclic movements around the earth each month.

20. The apparent shape of the moon which is seen at any one time is determined by the amount of the illuminated surface which can be seen.

21. The period of time required for the moon to go through a complete cycle of phases is definite.

22. In the complete cycle of the moon around the earth astronomers have chosen to indicate specific appearances as phases.

23. For easy reference the shapes of the moon at definite times each month have been given specific names of phases--first quarter, full moon.

24. When the phases of the moon are described in terms of first quarter, full, last quarter, and new moon, a definite appearance of the moon is understood.

25. The phases of the moon follow a regular order of new moon, first quarter, full moon, and last quarter.

26. The temperature on the surface of the moon varies greatly between the moon's day and night.

27. A lunar eclipse is caused by earth's shadow on the moon.

28. A solar eclipse occurs when the moon is in a straight line between the earth and the sun.

C. Sun.

1. The sun is the center of the solar system.

2. The sun is much farther away from the earth than is the moon.

3. The sun is in the Milky Way galaxy.

4. The sun is near one boundary of the Milky Way galaxy.

5. The sun is many times larger than any planet of the solar system.

6. The sun is very old.

7. The life expectancy of the sun is very great according to estimates.
8. The sun is a "young" star.
9. The sun gives out light in all directions.
10. The sun is so bright the stars cannot be seen during the day.
11. The sunlight contains all colors.
12. Light from the sun is the source of the energy for the manufacturing of all foods and fibers.
13. The way the sunlight strikes the tilted earth causes the seasons.
14. Because of the tilt of the earth in relation to the sun, some parts of the world have summer while others have winter.
15. The total daily amount of energy received from the sun by the earth is the same throughout the year.
16. The amount of energy received during any one day at any one place on the earth depends upon the position of the earth on its orbit.
17. The amount of energy absorbed at a specific location during a single day depends upon the directness of the sun's rays.
18. The sun's path across the sky is longer and higher in the summer than in winter.
19. The heat from the sun controls the temperature of the earth.
20. The innermost parts of the sun are hotter than its surface.
21. There are numerous, explosive flares on the sun (sunspots).
22. Sunspots seem to occur in cycles.
23. Sunspots create many changes on the earth's surface and in its surrounding magnetic field.
24. The auroras appear in the northern and southern skies simultaneously.

D. Solar System.

1. The solar system consists of the sun and the astronomical bodies that revolve around it.
2. Those parts of the solar system which were first observed were those closest and most apparent on the earth.

3. Inadequate and inaccurate studies of the solar system led to many false conclusions about the solar system.

4. As methods of observation improved, more distant or less apparent objects in the solar system were studied.

5. Present-day observations are being conducted to obtain further knowledge about the solar system.

6. The sun is the center of the solar system.

7. The earth is one of nine known major planets that revolve around the sun.

8. Physical characteristics of the planets vary greatly in the solar system.

9. The physical environment varies greatly on the surface of each planet in the solar system.

10. The atmospheres of all planets are not alike.

11. The atmosphere of a planet is most dense near the surface.

12. Different planets have different lengths of "days" and "years" than the earth.

13. Many of the repetitive astronomical phenomena require time lapses greater than the length of a man's life.

14. Things near the "equator" on the surface of a rotating body move faster than things near the "poles".

15. Many of the planets in the solar system have one or more natural satellites.

16. All of the planets rotate on an axis and revolve around the sun.

17. All planets and most of their satellites appear to rotate in the same direction as the earth.

18. All known planets in the solar system revolve around the sun in their own definite orbits.

19. Asteroids or planetoids are smaller fragments of earth-like materials which usually are orbiting around the sun in the region between Mars and Jupiter.

20. Some of the larger and/or nearer planets may be observed at night with the unaided human eye.

21. The movement of planets in the sky as viewed from the earth does not seem to be in the same pattern as the movement of the stars.

22. Planets are not a part of constellations.

23. As far as is known, there are no other inhabited planets in our solar system.

24. The law of universal gravitation aids astronomers in predicting the courses of planets.

25. All planets affect one another because of the law of universal gravitation.

26. The greater the distance a planet is from the sun, the less energy it receives from the sun.

27. Planets reflect light from the sun.

28. Evidence indicates that men cannot live on other planets within the solar system.

29. Any life on other planets in the solar system must be different from life on earth because of a radically different environment.

30. Meteors are stoney and metallic particles revolving around the sun, either individually or in streams.

31. Meteors are sometimes called "shooting stars", even though they are not stars.

32. Meteors are a very small part of the solar system.

33. Meteors start burning some time after they come into the earth's atmosphere because they are heated by the friction of the air.

34. Meteors are too small to be separately visible by reflected sunlight and are seen only when they enter the earth's atmosphere and become luminous bodies.

35. Meteors are drifting chunks of rock in the solar system which have come near enough to the earth to be attracted by gravity and have begun to burn because of the friction of air.

36. The unburned portions of original meteors which reach the earth's surface are called meteorites.

37. Comets are not solid bodies, but are conglomerates of many different kinds of materials.

38. Comets follow regular paths in space.

39. The paths of comets may intersect the orbits of some planets.

40. The "tail" of a comet always points away from the sun.

41. Comets do not produce their own light.

42. An eclipse of any object occurs when the light from that object is prevented from coming to the earth.

43. A solar eclipse occurs when the moon cuts off the light coming to the earth from the sun.

44. Partial solar eclipses occur each year.

45. A total solar eclipse may be observed only rarely and then only from certain small areas of the earth, the position of which may be calculated by astronomers.

46. A lunar eclipse occurs when the earth cuts off the light from the sun to the moon.

E. Stars and galaxies.

1. The universe is very big.

2. Early man observed and studied the stars.

3. Early observers drew many false conclusions.

4. The knowledge about the universe is constantly growing.

5. A telescope makes things appear closer.

6. More is learned about the universe as new instruments are developed or old instruments are improved.

7. A planetarium helps in locating stars and studying their apparent movement.

8. The identification of visible stars usually depends upon a number of factors; e.g., position in the sky, magnitude, season, and point of observation on the earth.

9. The identification of constellations through folklore is not science.

10. Groups of stars which in folklore form imaginary pictures are called constellations.

11. Sections of the sky are given names which are based on the name of the most prominent constellation in the area.

12. In locating the position of any star, reference usually is made to a specific section of the sky or constellation in which it is located.

13. Constellations are used to map positions of stars.

14. Constellations are groups of stars appearing to have the same relative motion when viewed from the earth.

15. Constellations are not groups of stars moving together through the universe in a set pattern.

16. Constellations appear fixed in relation to each other although individual stars are not moving through space at the same speed and/or in the same direction.

17. Over a very long period of time the constellations change in appearance.

18. Constellations which are in the northern sky in the northern hemisphere appear to rotate around Polaris.

19. Planets are not a part of constellations but appear to move slowly through some constellations during each year.

20. Directions on the earth can be told by the stars and constellations.

21. Polaris is the star located almost directly above the north pole of the earth.

22. The North Star will not always be Polaris.

23. Time at night may be determined by the position of the circumpolar constellations.

24. Stars consist of hot, glowing gases.

25. Stars do not twinkle, but changes in the atmosphere cause this illusion.

26. The stars which are visible at any time are determined by a number of factors; e.g., distance, magnitude, season, weather, location of the observer on the earth.

27. A stars color depends on its temperature.

28. The apparent brightness of a star is measured on a scale of brightness and is usually expressed in magnitude units.

29. The apparent brightness of a star depends on its distance, size and temperature.

30. Some stars are much farther away from the earth than others.

31. Far away stars appear smaller.

32. The stars move in definite paths which are not easily observed.

33. Stars are moving very fast.

34. Stars are believed to be spherical due to the gravitational attraction.

35. Stars do not appear to move with respect to each other because of great distances between them.

36. The apparent movement of stars in the night sky is due to the earth's rotation.

37. Near the poles, the stars appear to go around in concentric circles.

38. At the equator, the stars appear to move straight across the sky.

39. At any location on the earth there are many stars not visible because the earth obstructs the view.

40. "Shooting stars" are not stars at all, but are actually meteors.

41. Some "stars" may be parts of a solar system like the sun's solar system.

42. Some stars have burned out.

43. All stars are believed to be parts of galaxies.

44. Galaxies are huge collections or systems of stars.

45. The universe has many galaxies in it.

46. Different galaxies may have different shapes.

47. A few large-appearing stars are really galaxies.

48. Distant stars may actually be more than one star revolving around a common center (galaxies, binaries, etc.).

49. The solar system is part of the Milky Way galaxy (system of stars).

50. The Milky Way galaxy has a rather definite size and shape.

51. The Milky Way galaxy is moving outward away from other galaxies.

52. The Milky Way galaxy as viewed from the earth does not show its true shape and size.

53. Most distances in the solar system and the Milky Way galaxy are beyond comprehension.

54. Great distances in the universe are measured in terms of light years.

55. The light from most stars takes a long time to reach the earth.

56. The movements of astronomical bodies are influenced by the universal gravitation of all astronomical bodies.

57. The position of objects seen in the sky can be located in terms similar to latitude and longitude.

58. Small particles of solid material which are drifting in space are usually referred to as cosmic dust.

III. Teacher Preparation Activities

A. Personal.

1. Read the concepts which are included in the unit.
2. Read the recommended teacher references.
3. Become acquainted with the text and reference books that are selected for student use.
4. View the instructional films and filmstrips* for teacher references and enrichment.

   Films: The Realm of the Galaxies, Educational Testing Service, 1960. 19 min., color

   Stars and Star Systems, Encyclopedia Britannica Films, 1960. 16 min., B/W

   Filmstrips: The Earth in Space (Wonders of the Sky), Eye Gate House, 1956. (Color - upper elementary and junior high)

   Laws of the Sky (Wonders of the Sky), Eye Gate House, 1956. (Color - junior and senior high)

   Motions of the Earth in Space (The Earth and Its Moons) 1958.

5. View the instructional films and filmstrips* to be used with the pupils.

B. Teaching Materials.

1. Select the pupil texts and classify them as to reading level.
2. Select the reference books and classify them as to reading level.
3. Plan the arrangement of the classroom to create a stimulating atmosphere.
   a. Make a bulletin board display.
   b. Prepare a display of books to rouse children's interest.
   c. Develop a display of charts and maps of parts of the universe.
   d. Regroup the students' desks to fit teaching technique to be used.

---

* For annotations, refer to the bibliography near the end of this resource unit.

IV. Teacher Procedures

A. Introduction to the Teaching Procedures

Although each teaching procedure is different, no one technique for introducing the unit is especially suited to any particular procedure. The preparation of an intriguing bulletin board, the viewing of a carefully selected instructional film or filmstrip, the occurence of an interesting astronomical event or the visit of an expert with an astronomy hobby or career are equally valuable experiences which can be used as "interest getters". The children will begin to ask questions. The classroom teacher should encourage these questions and carefully correct any misconceptions which are evident in the children's statements.

B. Technique I - An activities approach

1. Teacher demonstration: The teacher steps before the class with a ball fastened to the end of string. A "Yo Yo" can be used. The teacher starts the ball swinging in a circle. The children may say, "Why are you doing that?", "What's that for?", or "I can do that". Perhaps a child may ask, "Why does the ball always move in a circle?" The teacher could use this opportunity to teach concepts on gravity and directional speed.

2. Teacher starts guiding children for the purpose of gaining constructive questions to be placed on the board. A child may be asked to be secretary who will write the questions on the board.

3. Teacher guides children into a discussion in which the class makes suggestions for some related activities which should provide information about these questions. Suggestions for the activities should be placed on the board by the teacher or secretary. (See the section on pupil learning activities for some suggestions for learning experiences.)

4. The class decides what suggestions to use. The class organizes into groups for study and research.

5. Each group of children prepares the materials needed for an activity and practices demonstrating and explaining the activity. Each group demonstrates and explains the activity to the entire class. The group chairman leads any discussion during which the class attempts to summarize the observation and uses this summary to arrive at an answer to one of the original questions.

C. Technique II - Class study approach

1. Class discussion: The teacher may initiate a discussion by asking some simple questions about the universe. "What do we already know about the universe?" (See Appendix A for a few suggestions for the type of questions which can be used for guiding recall and some anticipated outcomes for these questions.) Ask a good writer to be the secretary at the blackboard. As statements are given by members of the group, the secretary writes them on the board. The purpose of this discussion is to discover how much the children as a class group know about the universe. It is important that any misconceptions be challenged by pupils (and teacher) during the listing of these statements.

   Individual understandings may be checked by developing and using a pre-test of general information about the universe.

2. Class discussion: "What do we want to know about the universe?" The secretary writes questions on the board. The teacher should encourage the children to summarize and restate their questions to obtain a brief list of basic, or fundamental questions. (See Appendix B for some examples of this type of question.)

3. Class re-examination of their knowledge: 1) have someone in the class read from the board the answers to "What do we already know about the universe?"; 2) ask another member of the class to read the questions about "What do we want to know about the universe?"

4. Class study assignment: "Now we are ready to read from our texts to try to find the answers to our questions."

   The texts are passed out. During the rest of the period, those children who need help in reading or in using the table of contents and index could be grouped together and guided in their work. In some cases, individual help should be given. The reading should be completed and the class ready for a summation of its findings by the next class period.

5. Class discussion after reading: "What more have we learned about the universe?"

   The class' questions (which could now be grouped on a chart) are asked again and members of the class now have the opportunity to answer them, using their texts as authorities. As each question is answered, it should be checked off. A member of the class could ask the questions and do the checking. Unanswered questions could be delegated to individuals or groups for further study.

   If this technique is used as a part of the unit and not as a final evaluation the following evaluation might be used.

C. Technique II (continued)

Give the children a topic (such as "Stars") and ask them to discuss it without any teacher direction. One child may be called on to begin the discussion. When he finishes, he will call on another person who wishes to speak on the subject and so on. To close this discussion the teacher may call on someone else to evaluate all the information which has been given.

6. Class viewing: At this time, instructional films or filmstrips could be viewed.

   Filmstrips: The Sun and Its Family Society for Visual Education, 1957.

   The Sun and Its Planets (Earth and the Universe), Society for Visual Education, 1952.

   Film: Exploring the Night Sky Encyclopedia Britannica Films, Black and White, (10 minutes)

7. Visit the planetarium at the Minneapolis Public Library.

8. Evaluation of unit: The concepts that should have been taught should now be reviewed by the teacher. (See the section on evaluations for further suggestions.)

D. Technique III - An individual or group study approach

1. Suggestions for the organization of the study

   a. Set up, by class vote if possible, a directing group of about three pupils. This committee could be seated at a table facing the class. The committee has a list of topics numbered 1 through 17 which appear in the bibliography for Technique III. (The classroom teacher may prefer to use the list of questions listed in Appendix C.) The chairman reads all of the topics. These topics should be on the class chart and could be read to the class from the chart.

   b. Each member of the class now decides which topic he would like to work on. Two or more, as a committee, should work on some topics; on other topics, one pupil could work alone.

   c. The directing committee of three takes the responsibility, under teacher guidance, to record the pupil committees and their topics and to assist them in getting their materials, such as books, filmstrips, and instructional films. The directing group also does research on all topics, or certain topics. They may divide the topics into three sections, each taking a section for which to be responsible, and becoming authorities or "experts" (by study) to which their committees may come for help.

D. Technique III (continued)

   d. A set time and plan for research and preparation should be agreed upon. The following time schedule is suggested: four to five days for reading and three to four days for reporting to class.

   e. Methods of reporting to the class should be agreed upon.

2. Suggestions for methods of reporting

   a. Giving oral reports using notes or without notes

   b. Having questions and answers sessions

   c. Presenting a short oral report with charts or pictures, self-drawn or otherwise, shown on opaque projector

   d. Showing an appropriate instructional film or filmstrip: e.g., A Trip to the Moon,* Encyclopedia Britannica Films, 1957. filmstrip: Our Silvery Moon* (Wonders of the Sky), Eye Gate House, 1956.

   e. Presenting a creative drama

   f. Listening to tapes

   g. Showing slides--self-made or obtained from library

   h. Giving demonstrations to illustrate a concept

3. Evaluation by entire class

   a. Reviewing the original topics as stated on chart

   b. Answering the question, "What have we learned about the universe that we didn't know before?"

   c. Recalling and restating the concepts learned

4. Closing the unit

   a. Having a class trip to the planetarium at the Minneapolis Public Library

   b. Viewing the sky by night in groups or as a class, if possible

   c. Viewing an instructional film such as Exploring the Night Sky*

5. Evaluation of unit by teacher (See the section on evaluation for suggestions.)

* For annotations refer to the bibliography near the end of the resource unit.

Bibliography for Technique III:

a. Texts*:

(1) Solar system

	Grade Level
Baker, Arthur O., et al. 1955. *Your Science World*, pp. 92-95, Rand McNally.	6
Barnard, John Darrell, et al. 1959. *The Macmillan Science/Life Series, Book Four*, pp. 92-93, Macmillan.	4
Craig, Gerald S. and Katherine E. Hill. 1954. *Adventuring in Science*, "The Sun's Family," pp. 74-78, Ginn.	5
Dowling, Thomas I., et al. 1958. *The New Explaining Why*, pp. 172-173, Winston.	4
Frasier, George Willard, et al. 1959. *Singer Science Experiments*, p. 19, Singer.	5
Knox, Warren, et al. 1950. *The Wonderworld of Science--Book Five*, "The Solar System," pp. 149-178, Scribner's.	5
Schneider, Herman and Nina. 1955. *Science for Today and Tomorrow*, pp. 259-263, Heath.	6
Schneider, Herman and Nina. 1955. *Science In Your Life*, pp. 287-288, Heath.	4

(2) Sun

	Grade Level
Baker, Arthur O., et al. 1955. *Your Science World*, pp. 102-103, Rand McNally.	6
Blough, Glenn O. and Ida B. DePencier. 1950. *How the Sun Helps Us*, (Basic Science Education Series), Row Peterson.	3
Schneider, Herman and Nina. 1955. *Science for Today and Tomorrow*, "Solar Power," pp. 346-353, Heath.	6

* Page numbers in this bibliography refer to editions of texts as dated. Check these page numbers with the editions which are available at a specific school.

	Grade Level
Thurber, Walter A. 1955. *Exploring Science - Six*, "Time and Seasons," pp. 54-80, Allyn & Bacon.	6
(3) Milky Way	
Craig, Gerald S., et al. 1955. *Experimenting in Science*, "The Milky Way and Beyond," pp. 99-117, Ginn.	6
Schneider, Herman and Nina. 1955. *Science for Today and Tomorrow*, "The Home of the Solar System," pp. 279-281, Heath.	6
(4) Venus	
Craig, Gerald S. and Katherine E. Hill. 1954. *Adventuring in Science*, pp. 76-78, Ginn.	5
Schneider, Herman and Nina. 1955. *Science In Your Life*, "Venus," pp. 292-293, Heath.	4
Smith, Victor C., et al. 1956. *Science Through the Seasons*, (Science for Modern Living - Five), "Venus," pp. 202-205, Lippincott.	5
(5) Jupiter	
Frasier, George Willard, et al. 1959. *Singer Science Experiments*, "Jupiter," pp. 29-30, Singer.	5
Schneider, Herman and Nina. 1955. *Science In Your Life*, "Jupiter," pp. 296-298, Heath.	4
Smith, Victor C., et al. 1956. *Science Through the Seasons*, (Science for Modern Living-Five), "Jupiter," pp. 211-215, Lippincott.	5
(6) Mars	
Craig, Gerald S. and Katherine E. Hill. 1959. *Adventuring in Science*, "About Mars," pp. 79-80, Ginn.	5
Frasier, George Willard, et al. 1959. *Singer Science Experiments*, "Mars," pp. 28-29, Singer.	5
Schneider, Herman and Nina. 1955. *Science In Your Life*, "Mars," pp. 294-295, Heath.	4
Smith, Victor C., et al. 1956. *Science Through the Seasons*, (Science for Modern Living-Five), "Mars," pp. 205-208, Lippincott.	5

	Grade Level
(7) Moon	
Baker, Arthur O., et al. 1955. Your Science World, pp. 104-114, Rand McNally.	6
Craig, Gerald S. and Katherine E. Hill. 1959. Adventuring in Science, "The Nearest Sky Neighbor," pp. 65-73, Ginn.	5
Frasier, George Willard, et al. 1959. Singer Science Experiments, "The Earth and Moon," pp. 20-25, Singer.	5
Smith, Victor C., et al. 1956. Science Across the Land, (Science for Modern Living - Four), "Looking at the Moon," pp. 107-124, Lippincott.	4
(8) Saturn	
Craig, Gerald S. and Katherine E. Hill. 1959. Adventuring in Science, "About the Distant Planets," pp. 81-82, Ginn.	5
Frasier, George Willard, et al. 1959. Singer Science Experiments, "Saturn," pp. 31-32, Singer.	5
Schneider, Herman and Nina. 1955. Science In Your Life, "Saturn," pp. 298-299, Heath.	4
Smith, Victor C., et al. 1956. Science Through the Seasons, (Science for Modern Living - Five), "Saturn," pp. 215-218, Lippincott.	5
(9) Earth movements	
Baker, Arthur O., et al. 1955. Here and Away, "Day and Night," pp. 111-121, Rand McNally.	4
Dowling, Thomas I., et al. 1958. The New Explaining Why, pp. 161-171, Winston.	4
Dowling, Thomas I., et al. 1958. The New Understanding Why, "The Earth and the Seasons," pp. 77-120, Winston.	6
(10) Uranus, Neptune, Pluto	
Frasier, George Willard, et al. 1959. Singer Science Experiments, pp. 31-33, Singer.	5
Schneider, Herman and Nina. 1955. Science In Your Life, pp. 299-300, Heath.	4

	Grade Level
(11) Mercury	
Craig, Gerald S. and Katherine E. Hill. 1959. *Adventuring in Science*, pp. 75-77, Ginn.	5
Frasier, George Willard, et al. 1959. *Singer Science Experiments*, "Mercury," pp. 25-26, Singer.	5
Schneider, Herman and Nina. 1955. *Science In Your Life*, "Visit to Mercury," pp. 291-292, Heath.	4
Smith, Victor C., et al. 1956. *Science Through the Seasons*, (Science for Modern Living - Five), "Mercury," pp. 209-211, Lippincott.	5
(12) Planetoids or asteroids	
Craig, Gerald S. and Katherine E. Hill. 1959. *Adventuring in Science*, "The Little Planets," p. 83, Ginn.	5
(13) Comets	
Craig, Gerald S. and Katherine E. Hill. 1954. *Adventuring in Science*, "Comets Visit the Earth," pp. 86-87, Ginn.	5
(14) Meteors	
Craig, Gerald S. and Katherine E. Hill. 1959. *Adventuring in Science*, "Meteors Visit the Earth," pp. 84-86, Ginn.	5
Frasier, George Willard, et al. 1959. *Singer Science Experiments*, "Earth Visitors from Space," pp. 8-18, Singer.	5
Schneider, Herman and Nina. 1959. *Science for Today and Tomorrow*, "Meteors," p. 278, Heath.	6
(15) Stars	
Baker, Arthur O., et al. 1955. *Here and Away*, "What Are Stars?", pp. 123-131, Rand McNally.	4
Craig, Gerald S.and Katherine E. Hill. 1959. *Adventuring in Science*, "Beyond the Sun's Family," p. 88, Ginn.	5
Dowling, Thomas I., et al. 1958. *The New Explaining Why*, "The Universe," pp. 174-178, Winston.	4
Smith, Victor O., et al. 1956. *Science Beneath the Skies*, (Science for Modern Living - Six), "Studying the Stars," pp. 151-178, Lippincott.	6

	Grade Level
(16) Tools	
Barnard, John Darrell, et al. 1959. The Macmillan Science/Life Series, Book Four, pp. 83-87, Macmillan.	4
Craig, Gerald S. and Katherine E. Hill. 1954. Adventuring in Science, pp. 91-95, Ginn.	5
(17) History of astronomy	
Barnard, John Darrell, et al. 1959. The Macmillan Science/Life Series, Book Four, pp. 73-87, Macmillan.	4
Craig, Gerald S. and Katherine E. Hill. 1954. Adventuring in Science, pp. 89-92, Ginn.	5

Grade Level

b. Reference Books*:

(1) Sun

Gallant, Roy A. 1958. Exploring the Sun, Doubleday.

(2) Meteors

Zim, Herbert S. 1958. Shooting Stars, Morrow. 4-6

---

* For annotations refer to the bibliography near the end of this resource unit.

Visual Aids for Technique III:

a. Film*:

(1) Moon

A Trip to the Moon. Encyclopedia Britannica Films, 1957.

b. Filmstrips*:

(1) Sun

Our Sizzling Sun (Wonders of the Sky). Eye Gate House, 1956.

(2) Moon

The Moon (The Earth and Its Moon). Films for Education, 1958.

Our Silvery Moon (Wonders of the Sky). Eye Gate House, 1956.

(3) Stars

Constellations (Earth and the Universe). Society for Visual Education.

Stars and Galaxies (Earth and the Universe). Society for Visual Education, 1952.

c. Tapes, scripts, or records*:

(1) Tools

Radio Astronomy (Fun in Science).

Telescopes and Telescope Making (Fun in Science).

---

* For annotation refer to the bibliography near the end of this resource unit.

V. Pupil Learning Experiences

A. Comparing the size of the planets and the sun, and the distance between them.

Note: It is important to note that distances in space are so great that it is impossible to put sizes and distance together in any demonstration of the relative sizes of the planets and their distances from the sun.

Experience #1:

Materials needed:

tape measure

What to do:

The out-of-doors is needed to demonstrate distances between parts of the solar system. The teacher and the class might use the playground. Space the children at various distances to represent the relative distances of the planets from the sun. One child can be chosen to represent the sun and others can represent each of the planets. All the planets can be placed if the proper scale is used.

This activity could be used to develop an appreciation of space. For a table of average and relative distances for class use, refer to the first part of the chart, "Some Astronomical Facts and Approximations for Teaching," included in this unit.

This activity may be used as a "tie-in" with map work of drawing to a scale.

Experience #2:

Materials needed:

wrapping paper, about 25' long
pencil

What to do:

Pupils can get a clear idea of relative distances of various planets from the sun if they draw portions of the planets' orbits on a long sheet of wrapping paper. If the pupils assume the sun is at one end of the wrapping paper and use six inches to represent the distance of the earth from the sun, they can work out to scale the distances for the other planets, with a distance of approximately twenty feet for Pluto. The class may refer to the chart, "Some Astronomical Facts and Approximations for Teaching," to find a scale of relative distance which can be modified to the scale suggested.

Experience #3:

Materials needed:

modeling clay
paper maché
heavy wire, long enough to stretch diagonally across the classroom
fine wire

What to do:

One might start this project by asking the pupils, "What figures will we have to know in order to make a scale model showing the relative sizes of parts of the solar system? How can we adjust the figures to a scale?" Pupils should be urged to make their own plan and then carry it out.

From various sources children should get figures that tell diameters of the various planets. The teacher can refer to the chart, "Some Astronomical Facts and Approximations for Teaching" included in this unit. The children should decide on a scale that they can use in order to get all members of the solar system into the classroom.

Here is an opportunity to let the children try out their ideas and then remedy any mistakes they make. This is an example of making science and mathematics useful to one another.

Using clay and paper maché (or paper cut-out model) to make their models, they may be hung from a wire stretched diagonally across the classroom in the same order as they are found in the solar system. The teacher may wish to ask the children whether all the models have to be on the same size as the sun.

Experience #4:

Materials needed:

modeling clay	tagboard, large sheet
heavy wire, long enough to reach across the room	paper clips
fine wire, several feet	paste sticks
	pencil
	paper

The following chart gives the information needed to make the model:

	Approximate Diameter	Approximate Distance of Orbit from Sun	Number of Known Moons
Mercury	1/3 earth's diameter	1/3 earth's distance	none
Venus	slightly less than earth's diameter	2/3 earth's distance	none
Earth	8,000 miles	93,000,000 miles	1
Mars	1/2 earth's diameter	1½ times earth's distance	2
Jupiter	11 times earth's diameter	5 times earth's distance	12
Saturn	9 times earth's diameter	10 times earth's distance	9
Uranus	4 times earth's diameter	20 times earth's distance	5
Neptune	3½ times earth's diameter	30 times earth's distance	2
Pluto	½ earth's diameter	40 times earth's distance	none
Sun	108 times earth's diameter		
Moon	1/4 earth's diameter		

Experience #4 (continued)

What to do:

Make a ball of clay for the earth 1/4 inch in diameter. Then, use the above chart to find out how large the other planets should be made; e.g., Jupiter, eleven times 1/4 inches or 2-3/4 inches in diameter; Mars, 1/2 or 1/4 inch or 1/8 inch in diameter. Saturn must have a ring (really a series of 3 rings). Make Saturn's ring from tagboard. Make each ring about one inch wide. The diameter of the inner circle of the innermost ring should be greater than that of the model of Saturn, i.e., greater than 2-1/4". Push three paste sticks into the model of Saturn to make a support for the ring. Place the rings on the paste sticks.

As soon as you have made the models of the planets, run pieces of fine wire about a foot long through them. For each of the larger models, fasten a paper clip to the end of the wire as an anchor to keep the model from slipping off the wire. Bury this clip in the clay.

The sun can be made of tagboard as it is so large; clay would not be practical. Cut a circle out of tagboard. It will be 108 x 1/4 inch or 27 inches in diameter. Fasten the heavy wire across the room as high up as possible. Fasten the sun circle to the wall at one end of the wire. In order to keep the same scale, the earth should be hung 242" away from the sun. If the earth is placed 6" from the sun, the sun would have to be reduced to .06 inch, which is about the size of a pencil dot, in order to use this scale of distances. Although the representation of the solar system is distorted, for convenience, hang the clay ball representing the earth six inches from the sun. Calculate where to hang the others, using the scale 6 inches equals 93,000 miles.

Make tiny balls of clay for the moons of the planets. Fasten them to the planets with short pieces of wire.

Make a group of tiny balls of clay to represent the "planetoids" or "asteroids." Put them on the ends of pieces of fine wire, twist the free ends of the wires together, and hang the group between Mars and Jupiter.

B. Picturing star groups

Experience #1:

Materials needed:

umbrella
colored chalk or paint

What to do:

The inside of an umbrella may be used as a background. The handle may represent the axis of the earth. Let the children experiment with different kinds or colors of chalk, or with white paint in making the marks to represent the apparent relative locations of the stars in the most well-known northern constellations. (See the chart, "Twenty Stars of the First Magnitude", to learn which stars are brightest.)

Experience #2:

Materials needed:

cardboard box
construction paper
electric light or slide projector
scissors

What to do:

Leave the cover on the box and remove one end. Cut several pieces of paper the size of the end of the box. On each piece, map the shape of one constellation by punching holes to represent the stars. Use an electric light on an extension cord for lighting up the inside of the box. The light socket of the cord may be pushed part way through a hole cut into the remaining end of the box. Screw a lamp bulb into the socket, plug the cord into an electric outlet, and illuminate the inside of the box by turning the switch on and off. Take care that the box does not become overheated so that it becomes a fire hazard. The constellation maps can be held over the open end of the box so that the light shines through the holes, showing up the constellations very well. The children can work out details, e.g., the kind of paper to use, the brightness of the light bulb.

Experience #3:

Materials needed:

paper, heavy, dark
oatmeal carton
flashlight or reading lamp
pencil, sharpened

What to do:

Encourage children to observe stars and constellations in the evening sky. Whenever possible, the teacher might plan a night meeting with the class to assist the children in observing the stars. Plans for this evening star study should include inviting one parent to help each five children. However, in most cases the children will have to look for stars without assistance. When observations are made, reports should be made to the class.

To represent the stars seen, the observers can punch holes with a sharpened pencil in a sheet of heavy, dark paper--large holes for bright stars, small holes for the small stars. The top and the bottom may be removed from an oatmeal carton, a flashlight or reading lamp placed inside, and the star chart fitted over the end of the carton facing the children observing. A modification is to place the chart in the window. When a star is mentioned, it can be pointed out on the chart and its position in the sky indicated. If colors are desired, colored cellophane can be pasted over the hole.

Experience #4:

Make slides of constellations - 2" x 2" or $3\frac{1}{4}$" x 4" - and project them with the slide projector. Holes punched in paper with a needle can represent stars of different sizes and they will show up well on the projection screen. Designs and pictures can also be drawn or transferred onto glass slides and shown effectively by means of the lantern projector.

Experience #5:

Ask the children to make up a story about the stars in a constellation as did the ancient tribes. The teacher can prepare a star-grouping, such as Orion or Perseus, without telling the children what it is. Place this group on the blackboard and ask the children to write a story about what they can see in the constellation.

C. Making a planetarium

Experience:

Materials needed:

lamp base, discarded, wooden
board, $\frac{1}{4}$" x 2" x 18"
globe from ten cent store
spool, wooden
nail, one inch longer than diameter of globe
dowel rod, two inch length of 3/16" diameter (or a piece of nail) that fits loosely into the spool
brace
1" and 3/16" bits
glue

What to do:

Remove bulb from the light socket in the lamp base. Bore a hole one inch from the end of the board large enough for the end of the light bulb to pass through; the hole must be large enough to allow the board to turn easily around the light socket. In the other end of the board, bore a hole into which the dowel rod fits firmly. Insert the dowel rod through the hole, allowing one inch to extend up above the board. Glue the dowel rod in place. Punch holes in the globe at the north and south poles. Insert the long nail through these holes. Drive the nail into the spool so that the globe is at a $23\frac{1}{2}^{\circ}$ angle. Put the spool on the piece of dowel rod which is sticking up above the board. Be sure the spool turns easily. Put the other end of the board on the light socket, screw in the light bulb and plug the lamp cord into an electric outlet. The globe (earth) can be turned on its axis, and the board can be moved to turn the earth around the sun.

D. Demonstrating the phases of the moon

Experience #1:

Materials needed:

flashlight or projector
volleyball, white or light colored
(cover with aluminum foil for more reflection)

What to do:

Have one child hold the flashlight or projector to represent the sun. Another child holds the ball representing the moon. Two or three children observe from some place in the room which can be called the earth. To see the crescent moon, move the ball to a position where the children stand with the moon (ball) almost exactly between them and the sun. To see the moon at its quarter phase, move the ball to a position where the children are between the ball and the flashlight. Eclipses of the sun can also be demonstrated using this method. If a second larger ball is used to represent the earth, eclipses of the moon can be demonstrated, too.

Experience #2:

Materials needed:

scissors
paper
pins

What to do:

A bulletin board or blackboard can be used to illustrate the cause of the moon's phases. Phases of the moon can be pictured on a bulletin board, using cutouts to represent the children, ball and flashlight in activity #1. Rays of light leading to the moon can be cut out or drawn. Place several sets of cutouts in different positions on the bulletin board to represent different phases of the moon.

Experience #3:

Materials needed:

hat box, round
cardboard tubes, six or eight, from paper towels
tennis ball
filmstrip projector
shoe polish, black or paint, black, tempera
scissors
string, about 8" long
masking tape
glue

What to do:

Paint the inside of the hat box black. Glue one end of the string to the tennis ball. To simulate the moon, suspend the ball in the hat box by punching a small hole in the center of the cover, pushing the string through the hole and tying a knot in the string to prevent it from slipping. If necessary, the height of the ball should be adjusted so that the ball is in the center of the box. Make a round hole on one side halfway up the side large enough to allow the lens of the projector to fit in closely. Make holes, large enough for tubes to be fixed into them, at regular intervals around the side of the box on the same level as the hole for the light. Without touching the hat box, the children looking through the different tubes can see different phases of the moon. Some experimentation and adjustments by the teacher and pupils on details of the set-up may be necessary.

E. Observing the surface of the moon

Experience:

Materials needed:

binoculars

What to do:

A pair of binoculars can be used to observe the moon. After the children have seen pictures of the moon's landscape they are quite excited at the sight of the moon through glasses. If any child has had the experience of seeing the moon through a large telescope, let him describe it to the class. Observe the moon nightly for a month. The chart "Moon Changes," could be used to record the appearance and phase of the moon at each observation.

F. Studying meteors

Experience:

Materials needed:

none

What to do:

Encourage children to watch the late evening sky for "shooting stars." Urge them to describe what they see. The best times of year for this are during the annual meteor showers of December 10-16 and August 10-14.

G. Calculating the number of miles in a light year

Experience:

Materials needed:

pencil
paper

What to do:

Multiply the distance light travels in one second (186,000 miles) by 60 to find the distance light travels in a minute. Multiply your answer by 60 again to find the distance light travels in one hour. Multiply this answer by 24 to find the distance light travels in one day. Multiply this answer by 365 to find the distance light travels in a year, or the number of miles there are in a light year (5,865,696,000,000 miles).

Some time might be spent in helping the pupils to better comprehend the size of this number by a brief class discussion. The speed of light is 186,000 miles per second, which is equivalent to seven and a half times around the world in one second. It only takes about eight and one-third minutes for light to come to us from the sun.

H. Demonstrating the effects of rotation

Experience:

Materials needed:

needle, knitting, long
paper, two strips, fairly stiff
about 12" x 1"
large cork
common pins
stapling machine

What to do:

Push the knitting needle straight through the cork. Place one strip of paper over the other at right angles to each other, forming an exact plus sign. Staple the strips where they cross. Bend the strips of paper in the same direction forming two intersecting circles. Staple the circles where they meet and cross. Punch a hole through the center of each crossing of the paper circles. Slide the paper circles with the hole onto one end of the knitting needle. Be sure the crossings of the papers can move freely up or down the knitting needle. Fasten the other crossing nearer the cork to the cork with pins. Hold the other end of the long knitting needle between the palms of hands and rotate the needle rapidly. The paper circles flatten at their poles (where circles cross) just as the earth when molten was flattened as it rotated.

I. Learning why different stars and different groups of stars are seen at different times of the year

Experience:

Materials needed:

globe
flashlight

What to do:

Place the globe of the earth near the center of the room. Let one child holding the flashlight stand near the globe. The flashlight represents the sun when its light is on the globe. Have the other children stand about the room to represent stars and constellations. Have some children imagine themselves suspended from the ceiling, representing constellations above the Arctic Circle.

The children should develop a statement explaining what conditions are necessary to viewing the stars. With these ideas in mind the children should rotate the globe and at the same time revolve it about the "sun." The "sun" should always be turned towards the globe. Note the difference between rotation and revolution in this case.

The children should discover that some of the stars in the June sky are not the same as the stars in the January sky. All stars and constellations (not planets) appear to revolve around the North Star (Polaris). On the bulletin board this revolution can be illustrated by moving the constellation diagrams around Polaris a short distance each day. Note that the constellations, such as the Big Dipper, which is directly above and near the North Star, remains in the sky over these regions during the entire year as it revolves around Polaris.

J. Studying the forces acting on objects

Experience:

Materials needed:

water, pail of

What to do:

Tip on its side a pail half full of water. Gravity pulls the water toward the center of the earth. Holding the pail half full of water parallel with the waist, whirl the pail around you as fast as you can. The water stays in the pail even though the pail is turned on its side as it twirls. The earth's gravity pulls the water, but the water doesn't fall out. Allow time for free discussion to clarify these concepts. Directional speed (very often incorrectly called centrifugal force) pulls a whirling object at right angles to its radius. Directional speed is pulling the earth and other planets toward outer space, but the force of gravity between the planets and the sun keeps them from flying off into space. Each planet keeps traveling around the sun in the same orbit because gravity and directional speed are in balance.

K. Showing the earth receives little of the sun's total light and heat

Experience #1:

Materials needed:

string, about 5' long
chalk

What to do:

Draw a small arc of a great circle at one end of a large chalkboard. The easiest way to make this arc is to have a child hold one end of the string against the wall 4½ feet from the end of the chalkboard. Grasp the chalk and the other end of the string, pull it tight, and sweep the arc. This represents the sun. At the opposite end of the chalkboard, place a small circle ½ inch in diameter. This represents the earth. The children should verify the fact that these two drawings are made to the same scale of sizes. Trace rays from the arc of the sun out across the blackboard in different directions. Emphasize that the sun is not a circle but a huge ball giving out light and heat in all directions. A relatively small body such as the earth receives but a very small part of the total light and heat of the sun.

Experience #2:

Materials needed:

candle or electric light bulb
 with low wattage
volley ball

What to do:

Place the candle or electric light bulb in one corner of the room. Place the ball in the opposite corner. Move the ball towards the light noting whether it is more brightly lighted as it is moved closer. The children should notice that light and heat are given off in all directions, but that only a very small part of the light and heat is received by the ball when it is far from the candle or electric light. The children should draw conclusions about the amount of heat and light the earth receives from the distant sun.

L. Demonstrating an eclipse of the sun or moon

Experience:

Materials needed:

- basketball
- coffee can, empty
- tennis ball
- milk bottle
- reading lamp, projector, or flashlight

What to do:

Place the basketball on the open end of the coffee can. This ball represents the earth. Put the tennis ball on the mouth of the milk bottle. This ball represents the moon. Adjust the heights of the coffee can and/or milk bottle, if it is necessary, to put the centers of the basketball, tennis ball, and light bulb in line with one another when placed on a table. By manipulating this equipment, eclipses of the sun or moon may be shown, as well as moon phases, day and night and seasons.

M. Constructing a sundial

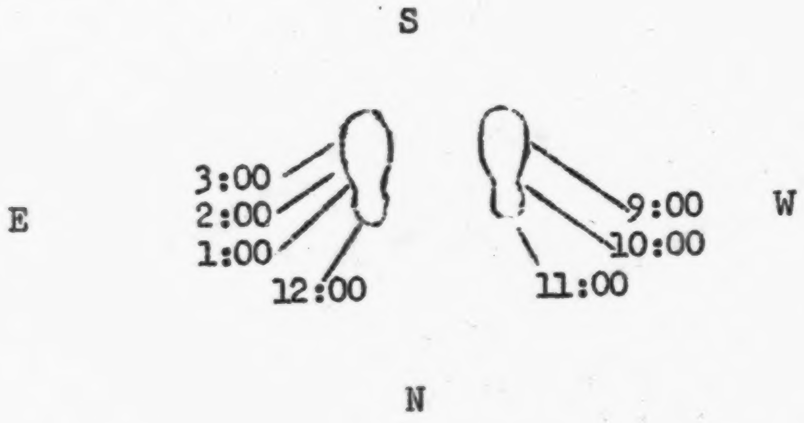
Experience #1:

Materials needed:

paint
clock

What to do:

Paint (permanently) the footprints of a child on school black top in a place where there is full sunlight all day long. Starting at nine o'clock in the morning, take the child out at hourly intervals and draw a line radiating from the footprints through the center of his shadow. Mark the time on each line. To use the sundial later, all a child needs to do is step onto the footprints and note the direction of the shadow.



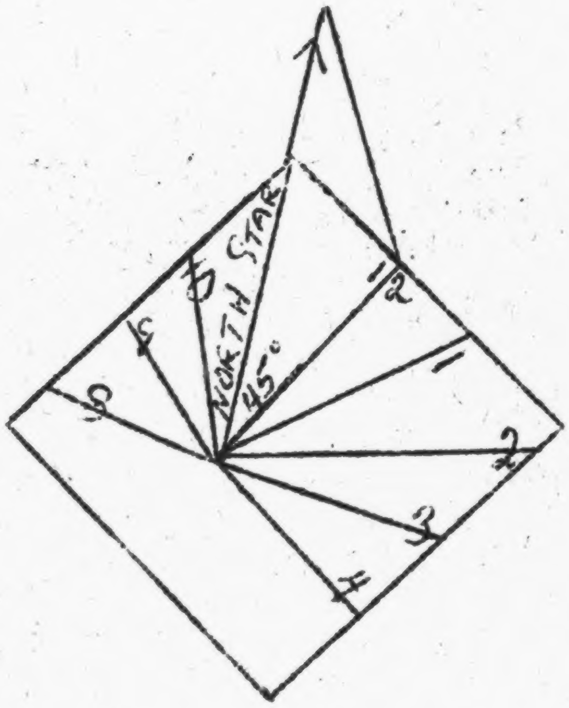
__Experience #2__:

__Materials needed__:

heavy cardboard for base
and triangle
glue

__What to do__:

Make a right angle triangle with base angle equal to the latitude of the place at which it is going to be used. (In Minneapolis, use 45°.) Glue this in position onto the cardboard square base. Turn the cardboard=base so that the hypotenuse points to the North Star and anchor it permanently in position. Mark the hours off on the baseboard by drawing lines along the edge of the shadow each hour during the day.



To withstand all weather, a sundial should be made of metal or painted wood.

VI. Evaluation

A. Evaluation of the individual child's learning

1. Does the child respond satisfactorily to informal oral quizzing?
2. Can the child do well on written examinations on facts and concepts included with the unit?
3. Can the child make acceptable contributions to class discussions about the unit's content?
    - a. Can he clarify his understandings of the concepts in the unit to a classmate?
    - b. Does he use the minimum vocabulary of this science unit?
    - c. Can he explain to guests the science understandings included in his displays and in the unit?
    - d. Does he feel the need for, look for, and use more accurate words than previously in explaining his understandings?
4. Does the child raise pertinent questions concerning the study throughout the unit?
5. Does the child participate actively and constructively in the planning, investigating, and discussion?
6. Does the child demonstrate accuracy and completeness of science understandings in written and oral science reports which are dependent on the content of this unit?
7. Does the child apply the science understandings to activities not included in the unit?

B. Evaluation of the teacher's success

1. Do the children respond satisfactorily to informal oral quizzing?
2. Can the children do well on written examinations on facts and concepts included with the unit?
3. Can the children carry on acceptable discussions about the unit's content?
    - a. Can they clarify to each other the concepts in the unit?
    - b. Do they use correctly the minimum vocabulary of this science unit?
    - c. Can they explain to guests the science understandings included in their displays and in the unit?
    - d. Do they feel the need for, look for, and use more accurate words than previously in explaining their understandings?
4. Do the children raise pertinent questions concerning the study throughout the unit?
5. Do the children participate actively and constructively in the planning, investigating and discussion?
6. Do the children strive for and demonstrate accuracy and completeness of science understandings in written and oral science reports which are dependent on the content of this unit?
7. Do the children apply the science understandings to activities not included in the unit?
8. Are the children beginning to show scientific attitudes toward phenomena?
    - a. Do they ask what, how, and why?
    - b. Do they ask questions more frequently?
    - c. Do they bring newspaper and magazine articles related to the unit to show and place on the science table?
    - d. Do they make repeated observations of the night sky throughout the year?

  - e. Do they ask questions as a result of their own observations?
  - f. Are they accurate in their observations and science information?
  - g. Are they accurate in recording observations?
  - h. Do they visit the planetarium throughout the year?

9. Do the children have an enthusiasm for learning?

10. Are the children now more interested in astronomy than they were when the study was begun, or has their interest decreased?

VII. Bibliography

A. Textbooks	Grade Level
Baker, Arthur O., et al. 1955. Here and Away, Rand McNally.	4
Baker, Arthur O., et al. 1955. Your Science World, Rand McNally.	6
Barnard, John Darrell, et al. 1959. The Macmillan Science/Life Series, Book Four, Macmillan.	4
Blough, Glenn O. and Ida B. DePencier. 1950. How the Sun Helps Us, (Basic Science Education Series), Row, Peterson.	3
Craig, Gerald S. and Katherine E. Hill. 1954. Adventuring in Science, Ginn.	5
Craig, Gerald S., et al. 1955. Experimenting in Science, Ginn.	6
Dowling, Thomas I., et al. 1958. The New Explaining Why, Winston.	4
Dowling, Thomas I., et al. 1958. The New Understanding Why, Winston.	6
Frasier, George Willard, et al. 1959. Singer Science Experiments, Singer.	5
Knox, Warren, et al. 1950. The Wonderworld of Science--Book Five, Scribner's.	5
Parker, Bertha Morris. 1957. Beyond the Solar System, Row, Peterson.	5
Parker, Bertha Morris. 1959. The Earth's Nearest Neighbor, Row, Peterson.	5
Parker, Bertha Morris. 1958. The Sky Above Us, (Basic Science Education Series), Row, Peterson.	5
Parker, Bertha Morris. The Sun and Its Family, (Basic Science Education Series), Row, Peterson.	8
Schneider, Herman and Nina. 1955. Science for Today and Tomorrow, Heath.	6
Schneider, Herman and Nina. 1955. Science in Your Life, Heath.	4
Smith, Victor C., et al. 1956. Science Across the Land, (Science for Modern Living - Book Four), Lippincott.	4

Textbooks - (continued)	Grade Level
Smith, Victor C., et al. 1956. Science Beneath the Skies, (Science for Modern Living - Book Six), Lippincott.	6
Smith, Victor C., et al. 1956. Science Through the Seasons, (Science for Modern Living - Book Five), Lippincott.	5
Thurber, Walter A. 1955. Exploring Science Five, Allyn and Bacon.	5

B. Reference books for pupils

Asimov, Isaac. 1959. The Clock We Live On, Abelard. This is a book for better readers. After reading this book the children will look at a clock and calendar with new respect.

Branley, Franklin M. 1960. The Moon Seems to Change, Crowell. In clear, concise, simple language the text explains the reasons for the changes in the moon. The illustrations do much to clarify relationships between the earth, sun, and moon. This book is excellent for slow readers.

Branley, Franklin M. 1958. The Nine Planets: Exploring Our Universe, Crowell. This book contains descriptive information about all the planets in the solar system. It includes an explanation of how scientists procure this information.

Freeman, Mae and Ira. 1953. Fun With Astronomy, Random House. This book will help the child discover interesting things about what there is in the sky. Concepts are clearly stated. Experiences are described and clearly illustrated with photographs and diagrams. A rocket trip to the moon is experienced. The print and the format are good.

Freeman, Mae and Ira. 1959. The Sun, the Moon, and the Stars, Random House. This is a simple book on astronomy. The book attempts to answer a few of the questions most often asked by children about the universe.

Gallant, Roy A. 1958. Exploring the Sun, Doubleday. This book presents a history of the study of the sun and explains the studies of the sun being carried out today.

Gamow, George. 1959. The Moon, rev. ed., Abelard. This book contains interesting, detailed information about the moon.

Goodwin, Hal. 1954. The Real Book About Stars, Doubleday. In this book the reader is taken on a journey of exploration to all parts of the solar system. The universe and eclipses are other topics included.

Grey, Vivian. 1959. The First Book of Astronomy, Watts. This is a thrilling story of the heavens, well illustrated with charts, drawings and pictures.

Lauber, Patricia. 1960. All About the Planets, Random House. This book discusses the major parts of the solar system. It includes a simple but detailed description of the moon. The book presents a discussion of the possibility of life on other planets.

Reference books for pupils - (continued)

Lauber, Patricia. 1959. The Quest of Galileo, Doubleday. This book tells the story of Galileo in clear and vivid terms. It is very well illustrated in color.

Lewellen, John. 1959. The True Book of Moon, Sun and Stars, Harvey House. This book answers questions about the composition of the moon and how it moves around the earth. The book contains an explanation of the relationship of the earth to the moon, sun, and other stars.

Munch, Theodore W. 1959. What Is a Solar System, Benefic Press. This book briefly and simply presents information about the members of the solar system.

Page, Lou Williams. 1959. A Dipper Full of Stars, Follett. This book gives excellent information about locating star groups. It provides good material about the parts of the solar system.

Posin, Daniel Q. 1961. What Is a Star, Benefic Press. This book gives extensive information about the stars.

Reed, W. Maxwell. 1960. The Stars for Sam, rev. ed., Harcourt, Brace. This book has a comprehensive coverage of the field of astronomy. For the above average student.

Ruchlis, Hy. 1958. Orbit - A Picture of Force and Motion, Harper. This book describes Sir Isaac Newton's Laws of Motion and his Universal Law of Gravitation in vivid words and startling pictures.

Schneider, Herman and Nina. 1951. You Among the Stars, Scott. This is an elementary book of astronomy describing the plan of the universe. This book uses objects familiar to the child to explain science facts.

Tannenbaum, Beulah and Myra Stillman. 1958. Understanding Time, McGraw Hill. This book traces the history of time measurement and explains the principles behind many time measuring instruments.

White, W. B. 1958. Neighbors in Space, Rand McNally. This book gives the mythological background of constellations in a very readable way with good illustrations. Also it describes and pictures the solar system briefly.

Reference books for pupils - (continued)

Wyler, Rose and Gerald Ames. 1959. The Golden Book of Astronomy, Golden Press. This book provides detailed information about many phases of astronomy.

Zim, Herbert S. 1958. Shooting Stars, Morrow. This is a clear, compact book about meteors and meteorites.

Zim, Herbert S. 1958. The Sun, Morrow. This is an easy to read book containing excellent illustrations in black and white.

C. General reference for the teacher

Skilling, William T. and Robert S. Richardson. 1959. Brief Text in Astronomy, Holt.

D. Professional literature for the teacher

Blough, Glenn O. and Marjorie H. Campbell. 1954. Making and Using Classroom Science Materials in the Elementary School, "The Earth and the Sky", Dryden.

Blough, Glenn O., et al. 1958. Elementary School Science and How to Teach It, rev. ed., Chapters 8A, 8B, 9A, 9B, Dryden Press.

Burnett, R. Will. 1953. Teaching Science in the Elementary School, "Learning about the Earth, Other Planets and Stars," Rinehart.

Craig, Gerald S. 1958. Science for the Elementary-School Teacher, (new edition), Ginn.

Nelson, L. W. and G. C. Lorbeer. 1955. Science Activities for Elementary Children, W. C. Brown.

Smith, J. Russell. Teaching a Unit in Astronomy, Vantage Press, New York.

VIII. Visual Aids

A. Instructional Films: Available from Audio-Visual Department

For the students:

A Trip to the Moon, Encyclopedia Britannica Films, 1957, 16 min., color.

Exploring the Night Sky, Encyclopedia Britannica Films, 1956, 10 min., B/W.

For the teacher and advanced students only:

The Realm of the Galaxies, Educational Testing Service, 1960. 19 min., color.

Stars and Star Systems, Encyclopedia Britannica Films, 1960, 16 min., B/W.

B. Filmstrips: Must be available in your building

For the students:

Constellations (Earth and the Universe), Society for Visual Education, 1952.

The Milky Way (Wonders of the Sky), Eye Gate House, 1956.

The Moon (The Earth and Its Moons), Films for Education, 1958.

Our Silvery Moon (Wonders of the Sky), Eye Gate House, 1956.

Our Sizzling Sun (Wonders of the Sky), Eye Gate House, 1956.

Stars and Galaxies (Earth and the Universe), Society for Visual Education, 1952

The Sun and Its Family, Society for Visual Education, 1957.

The Sun and Its Planets (Earth and the Universe), Society for Visual Education, 1952.

For the teacher and advanced students only:

The Earth in Space (Wonders of the Sky), Eye Gate House, 1956.

The Earth's Shape and Size (The Earth and Its Moons), Films for Education, 1959.

Laws of the Sky (Wonders of the Sky), Eye Gate House, 1956.

Motions of the Earth in Space (The Earth and Its Moons), Films for Education, 1958.

C. Tapes, scripts, or records (from Fun in Science Series--available in the Radio-Television Department)

Aurora Borealis and Air Glow The children learn about the relationship between northern lights and sunspots.

The Earth, Its Rotation and Revolution The principles of the rotation of the earth on its axis and its revolution around the sun are o explained to the children.

Eclipses - Moon and Sun The children visit the science museum to learn about the eclipses, discuss superstitions connected with eclipses and learn the cause of eclipses.

Gravity Cy comes to visit the children and they get a better idea of why dishes fall down instead of up, how gravity holds the universe together and how"gravity" differs on different planets.

Moon Watchers Cy takes children to the roof of the Mechanical Engineering Building at the University of Minnesota where they interview a member of the Moon Watchers Club. During the interview the children learn how the telescopes, microphones and tables are arranged for moon watching, why satellites are difficult to see and why there are moon watchers.

Night Sky in December The children stargaze on a cold night in December. Cy explains the Star of Bethlehem, constellations,, planets, and the North Star. There is an interesting interlude from Biblical times.

Radio Astronomy The children visit an observatory where tthey look through a telescope; later they see a radio telescope. Cy helps them understand the use of a radio telescope.

Sky Sights Cy gives the children a good picture of what Northern Lights are; they also learn about sunspots and magnetic storms.

Solar Activity and Atomic Energy The children learn how the sun causes their television station to fade out and channel six from Duluth to come in.

The Solar System The children learn important facts about the solar system, including the comparative size, names and orbits of planets.

The Sun's Family Joan wishes something would happen as she sits looking at the sky. Redda suggests they play astronomers.

Telescopes and Telescope Making The children visit the Crafts Room at the Science Room of the Minneapolis Public Library to learn how a telescope is made.

A Trip to the Planets Oliver, Bill, Redda and Joan take an imaginary trip around the solar system with Cy by rocket ship.

D. CHARTS

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

SOME ASTRONOMICAL FACTS AND APPROXIMATIONS FOR TEACHING

FACTS	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
Average distance from sun in millions of miles	36	67	93	141	489	886	1,782	2,793	3,670
Relative for class use Earth to moon—240,000 miles	4"	8"	1'	18"	5'	10'	20'	30'	40'
Diameter in miles	3,000	7,600	8,000	4,300	88,000	74,000	31,000	33,000	3,500
Relative for class use (Sun—864,000 miles —108" Moon—2,000 miles —1/4")	1/3"	3/4"	1"	1/2"	11"	9"	4"	4½"	1/2"
Known satellites	0	0	1	2	11	9	5	2	0(?)
Time required to travel around the sun (period of revolution in earth years	0.24 (88 days)	0.615 (225 days)	1 (365¼ days)	1.88 (687 days)	11.86	29.5	84.0	164.8	248.0
Mass (weight) based on the earth as 1.	0.04?	0.8?	1	0.11	317	95	15	17	0.1(?)

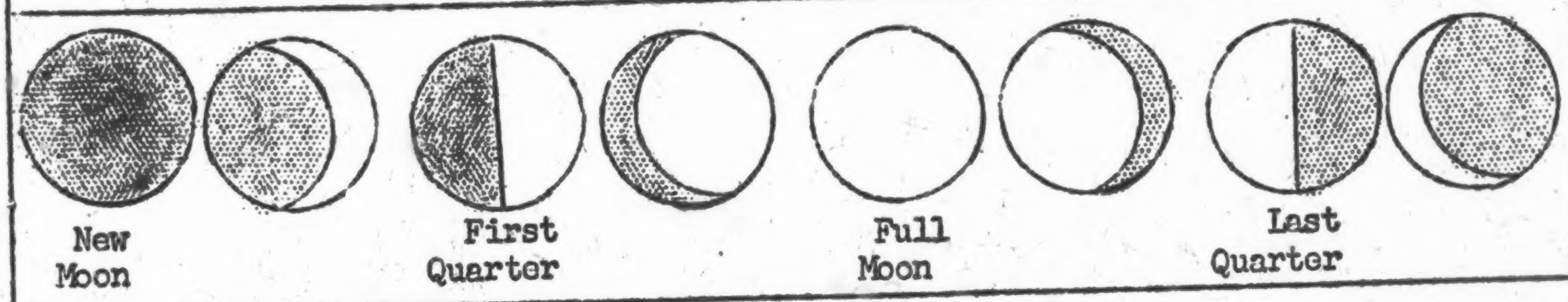
MINNEAPOLIS PUBLIC SCHOOLS

Science Department

TWENTY STARS OF THE FIRST MAGNITUDE
(in order of brightness)

Star	Distance in Light Years	Constellations
Sirius	8.3	Canis Major ("The Great Dog")
Canopus	200	Argo ("The Ship")
Alpha Centauri	4.3	Centaurus ("The Centaur")
Vega	26	Lyra ("The Lyre")
Capella	50	Auriga ("The Chariot")
Arcturus	40	Bootes ("The Herdsman")
Rigel	600	Orion ("The Hunter")
Procyon	10.4	Canis Minor ("The Little Dog")
Achernar	70	Eridanus ("The River")
Beta Centauri	90	Centaurus ("The Centaur")
Altair	16	Aquila ("The Eagle")
Betelgeuse	300	Orion ("The Hunter")
Alpha Crucis	100	Crux ("The Cross")
Aldebaran	60	Taurus ("The Bull")
Pollux	32	Gemini ("The Twins")
Spica	200	Virgo ("The Virgin")
Antares	400	Scorpio ("The Scorpion")
Fomalhaut	24	Piscis Australis ("The Southern Fish")
Deneb	400	Cygnus ("The Swan")
Regulus	60	Leo ("The Lion")

MOON CHANGES


New Moon
First Quarter
Full Moon
Last Quarter

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY

Minneapolis Pubilc Schools
Science Department

Suggested Supplies and Equipment

aluminum foil

ball, tennis
basketball
binoculars
bits, 1" and 3/16"
board, $\frac{1}{4}$" x 2" x 18"
box, cardboard
brace
bulb, electric light with
   low wattage

can, coffee, empty
candle
cardboard, heavy
carton, oatmeal
chalk
chalk, colored
clay, modeling
clock
cork, large

flashlight

globe
glue

hat box, round

lamp, reading
lamp base, wooden
light, electric

meteorite
milk bottles

nail
needle, knitting long

paint, black, tempera
paint, white
paper clips
paper, construction
paper, heavy, dark
paper maché
paper, 2 strips, fairly stiff,
   about 12" x 1"
paper, wrapping, about 25' long
paste sticks
pencil, sharpened
pins
pins, common
projector, filmstrip
projector, slide

rod, dowel, 2" length

scissors
shoe polish, black
spool, wooden
stapling machine
string, 5 feet long
string, 8 inches long

tagboard, large sheet
tape, masking
tape measure
tennis ball
tubes, cardboard, 6 or 8

umbrella

volleyball, white or light colored

water, pail of
wire, fine
wire, heavy

APPENDICES

Appendix A

Questions for guiding recall	Anticipated outcomes
1. What are the objects that we can see in the (day and night) sky?	Sun, moon, stars.
2. Which of these objects is most important to us? (The sun) Why?	The earth receives light from the sun, and some light from the moon. The sun gives us heat. The sun causes our seasons. The sun is necessary for life. Life on earth would be impossible without the sun. (You can start a fire with the sun.)
3. Why is it that we are able to see these objects in the sky?	The sun is made of hot, glowing, dense gases. The sun is our nearest star. The moon "shines" by reflected light from the sun. The stars are like our sun. The stars give off light.
4. How do we find out things about the sun, moon, and stars?	By watching the skies. By reading about the stars and planets. By looking at pictures in magazines and books. By watching television science programs. By watching movies. By listening to informed people.

Appendix B

Basic or fundamental questions

1. How do distances between planets, sun, and distant stars compare?
2. What keeps planets in orbit?
3. From the knowledge we have today, what can we say about life on other planets?
4. In what ways are the earth and moon alike; and how are they different as to atmosphere, soil or geology, climate, size, resources for life?
5. Why do we know that the sun is the center of the solar system?
6. How big is the universe?

Appendix C

Questions including some of the content of the unit

1. What bodies make up the solar system?
2. What keeps the planets in their paths?
3. Why is the sun important to us?
4. What is the Milky Way?
5. What can we discover about Venus? Why is Venus sometimes called the "evening" or "morning star?"
6. What can we discover about Jupiter?
7. Is life possible on Mars?
8. What can we learn if we take a trip to the moon?
9. What can we discover about Saturn?
10. What are the different movements of the earth?
11. Do we know that no one can possibly live on Uranus, Neptune, and Pluto?
12. Why is Mercury seldom seen?
13. What are the planetoids or asteroids?
14. What is a comet?
15. What causes "shooting stars?"
16. What is the difference between stars and planets?
17. How do we find out things about our universe?
18. How did the study of the universe begin?

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

MEMORANDUM

To: Grade Five Supplement Holders

From: Science Department

Re: Resource materials for the Major Topic, Living Things, Grade 5

- -

A set of "Suitcase Loans" has been made available recently by the Science Museum of the Minneapolis Public Library. Many of these display cases are appropriate for use with the Grade 5 Major Topic -- Living Things.

The "Suitcase Loans" available are:

EXPLORING OUTDOORS

E-1	Bird Nest, Puffballs, Goat's Beard, Bracket Fungi.
E-2	Shelf Fungus, Mud Dauber Nest, Tumbleweed, Galls, Lichens.
E-12	Exploring Outdoors - Pebbles, Bird's Nest, Galls, Shelf Fungus, Lichens.
E-13	Exploring Outdoors - Galls on a twig, Rocks with fossils, Mud Dauber wasp nest, Goat's Beard, Puffballs on tree bark.

These materials may be checked out and returned only at the Main Library. They are charged on your library card.

Since they are about 30" x 24" x 5", it would seem advisable to select only one or two cases at any one time. The "Suitcase Loans" are display cases containing mounted specimens and a glass front, Each case stands erect and could be used to stimulate interest in the unit or for continued motivation. These cases may be kept for as long as thirty days, but it may be advisable to change them more frequently.

Please inform the Science Office of your reactions to this material. Perhaps we can be instrumental in providing guidelines for the development of future suitcase loans.

JLP/md
11-3-65

MINNEAPOLIS PUBLIC SCHOOLS
Science Department

MEMORANDUM

To: Grade Five Supplement Holders

From: Science Department

Re: Another source of resource materials for the Major Topic, Living Things, Grade 5

- -

A set of "Suitcase Loans" has been made available recently by the Science Museum of the Minneapolis Public Library. Many of these display cases are appropriate for use with the Grade 5 Major Topic -- Living Things.

The "Suitcase Loans" available are:

SEA LIFE

S-2 Sea Life - Starfish, seahorse, sea urchin, sand dollar, coral, sea shells.

S-4 Sea Life - Starfish, hermit crab in a shell, horseshoe crab, barnacle group, shells, coral.

S-5 Horseshoe crab, starfish, sand dollar, sea urchin, worm shell, razor clam, snail with barnacles, coral.

These materials may be checked out and returned only at the Main Library. They are charged on your library card.

Since they are about 30" x 24" x 5", it would seem advisable to select only one or two cases at any one time. The "Suitcase Loans" are display cases containing mounted specimens and a glass front. Each case stands erect and could be used to stimulate interest in the unit or for continued motivation. These cases may be kept for as long as thirty days, but it may be advisable to change them more frequently.

Please inform the Science Office of your reactions to this material. Perhaps we can be instrumental in providing guidelines for the development of future suitcase loans.

JLP:md
9-22-65

A SIMPLIFIED PLANT CLASSIFICATION

Structures						Functions		
Leaves	Stems	Roots	Seeds	Flowers	Major Divisions	Make Food	Produce Embryo Plants	Have Vascular System
Yes								
					Thallophyta			
						No		
					Fungi			
					Algae	Yes		
							No	
	No							
							Yes	
	Yes				Bryophyta			
					Liverworts			
					Mosses			No
		No						
		Yes			Pteriodophyta			Yes
					Clubmosses			
					Horsetails			
					Ferns			
			No					
			Yes		Spermatophyta			
					Gymnosperms (cone-bearers and softwoods)			
				No				
				Yes	Angiosperms			
					Monocotyledons (grass and cereals)			
					Dicotyledons (broad-leafed plants)			

SOME IDEAS ON HOW TO MAKE MICROSCOPE SLIDE MOUNTS

By: Dr. J. Hervey Shutts
Consultant in Science
Minneapolis Public Schools

Plant Cells

1. Remove a very small piece of thin brown onion skin from a dry onion. Place it on a clean microscope slide and moisten it with a drop of water. When the skin has become completely soaked by the water, cover the slide with a second microscope slide. Place the double slide on a compound microscope and look for starch crystal and cell wall structure of the dead plant cells.

2. Cut an extremely thin slice of cork from a commercially prepared cork stopper using a sharp, single edge razor blade. Mount the slice on a microscope slide with a drop of water. Cover with another microscope slide and place the double slide on the compound microscope. Near the edge of the slice, where it is thin, look for the walls of the dead plant cells.

3. Remove the thin dry layers on the outside of a fresh onion. Hold the onion steady on its side on the surface of a table. Use a sharp single edge razor blade to cut a very thin slice from the upper round surface of the onion bulb. Place the slice on a microscope slide with a drop of water. Cover with another microscope slide. With a compound microscope view the edge section of the slice to locate a place thin enough for study of the cell structures.

4. Remove a leaf from an Elodea plant in your aquarium. Mount it in a drop of water between two microscope slides. Place the slides on a compound microscope. Look for "streaming" protoplasm in the living cell plant, using at least 100X magnification.

5. In a similar manner to No. 3 make a very thin tangential slice of the outer covering (commonly called the peel) of a potato. Mount it with a drop of water between two microscope slides. Place on a compound microscope and examine the cell structures.

6. In a similar manner to No. 3 make a very thin tangential slice of a peeled potato. Mount the slice in a drop of water between two microscope slides. Place on a compound microscope and examine for cell structures and contents. In these cells you will be able to distinguish starch granules. Examine them carefully as to general size and shape.

7. Starch granules have different characteristic appearances according to their origin in Irish potatoes, field corn, wheat, oats, barley, lima beans, popcorn. Examine these and other forms under the compound microscope if time permits. Examine some corn starch as purchased from the grocery store, on a microscope slide under a compound microscope to identify its origin by shape and size of starch granules.

Animal Cells

1. Cut a small cork stopper in half. Cut a very thin slice of any fresh or fixed animal tissue to be studied. Cut a narrow strip of material from the thin slice. Place the strip between the two halves of the cork stopper. Use a very sharp, single edged razor blade to cut a very thin slice of cork and tissue. Continue slicing until the section cut contains a very good transparent area of the animal tissue for study. Mount the tissue on a slide in a drop of water. Use a second slide to cover the tissue if desired. Look for the characteristic shape, size and contents of these animal cells. A pencil sketch on paper may help you to remember the appearance of some of the cells.

2. Place a drop or two of blood on a microscope slide near one end. Rest one end of a second microscope slide on the first slide. Pull it along until it contacts the drop of blood and then push it rapidly to the other end of the first slide, spreading the blood the length of the slide. Place a few drops of Wright's Blood Stain on the "blood smear" slide and drain over a watch glass or caster dish. Dry the slide by slightly warming, not heating, over a Bunsen burner or candle. Look for red blood cells as coins which are thin in the center or as stacks of coins.

For Examination of Pond Life

1. Heat some water in a beaker. Place a smaller container of petroleum jelly (vaseline) in the beaker to melt the vaseline. Dip a cylindrical object with a smooth circular open end (cutter for hole in doughnut or test tube without a rim) into the melted vaseline. Place the end of the cylinder flat against a cool microscope slide. Remove the cylinder and allow the vaseline ring to solidify. Use a medicine dropper to place a small amount of freshly collected pond water inside of the ring. Use a cover glass to cover the ring if desired. Look for evidence of plant and animal life with a compound microscope. If you have collected your pond water in the right place you may have some fairy shrimp, water fleas and pieces of algae.

JHS:nm
6-5-62
recopied 12/21/64
JHS:lvl